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THE COMPUTER AS AN AID IN DYE DIFFUSION STUDIES

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THE COMPUTER AS AN AID IN DYE DIFFUSION STUDIES

by

Emanuel Mehr

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59

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Table of Contents

	Page
1. Introduction	1
2. Physical Description	3
3. Data Preparation	6
4. Preliminary Program	10
5. Data Presentation Programs	13
A. One-dimensional programs	14
a) Program XYZ	16
b) Program TYZ	17
c) Program TXZ	21
B. Two-dimensional programs	22
6. Further Research	26
References	29
Appendix I - Computer Results	31
Appendix II- Computer Programs	44

List of Figures

	Page
Fig. 1. Sample fluorometer tape	5
Fig. 2. Calibration line	6
Fig. 3. Concentration vs time	16
Fig. 4. Table - Preliminary Program	32
Fig. 5. Graph - Program XYZ	33
Fig. 6. Graph - Program TYZ	34
Fig. 7. Graph - Program TYZ	35
Fig. 8. Graph - Program TYZ	36
Fig. 9. Graph - Program TYZ	37
Fig. 10. Graph - Program TYZ	38
Fig. 11. Table - Program TYZ	39
Fig. 12. Graph - Program TXZ	40
Fig. 13. Graph - Program TZ	41
Fig. 14. Graph - Program TZ	42
Fig. 15. Graph - Program TZ	43-73

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I. Introduction

In order to enable engineers and scientists to predict variations in water quality as waste discharges are altered, it is necessary to establish a large body of information about water systems. Chemical, biological and hydrodynamic phenomena are involved. While general physical and mathematical relationships for the chemical and biological components can often be ascertained, the hydrodynamic elements are usually undetermined.

Factors which influence the movement, by diffusion and advection, of material discharged into a water body are mass, wind, rain, temperature, tides and complex boundary conditions such as shorelines and bottoms, which are subject to change by sedimentation, dredging, dikes and piers. These intricate variables greatly increase the complications involved in the analysis of the hydrodynamic constituent.

Nevertheless, quick and economical methods of investigating the hydrodynamics of water bodies must be developed. The compilation of empirical data gleaned from performing experiments which consist of building treatment facilities or moving the location of discharge outlets is impractical because of the large expenditures which would be involved.

One method which is being used by scientists to attack the hydrodynamic problem is the release of a fluorescent dye to simulate a pollutant. The movement of the dye concentration is then traced in space and time. Rhodamine B, which is one of the dyes used for this purpose, is a reasonably stable red dye which can be detected at low concentrations (to 0.02 parts per billion) with reliability. No harmful effect to any form of life has been observed for the concentration used. Furthermore, the fluorescent properties are not greatly affected by the

normal chemical characteristics of the water bodies studied. (An exception is chlorinated water which bleaches the dye.)

The idea for this study arose in talks with Ronald Bunce and T. A. Wastler of Johns Hopkins University. (Both men are now in the Division of Water Supply and Pollution Control of the U. S. Department of Health, Education and Welfare.) It was shocking to discover that many weeks of drudgery were necessary before the data could be interpreted intelligently. Furthermore, data were accumulating at a faster rate than they could possibly be processed. This led to an ever growing backlog of overflowing desk drawers, and lengthening time gaps between the acquisition of the data and its processing.

This report represents an attempt to break this log-jam by the judicious use of computers. Essential data are punched on cards. Preliminary programs scan the data and find glaring errors. After manual corrections the concentrations, geographical locations and time are determined for every data point and saved for further programs. Computer programs have been written to study any particular one or two dimensional section of the dye distribution surface in space and time. Various graphs are drawn and pertinent statistics listed.

At the start of this study, it was hoped that much of the data interpretation could be programmed. It was naively expected that "some day" the state of the art would be developed to such a degree that raw data could be thrown into the magic hopper and out would come the final report. Before very long it was realized how impossible this Utopian dream was.

There is no limit to the power of computers to program definite algorithms. However, one must know exactly what is expected and what the results will be, e. g., raw atmospheric pressures have been programmed

to yield automatically the daily weather maps. In our case, however, we are dealing with a research problem. We do not know exactly what we are looking for. In fact, if we knew all the answers, the dye experiments would not be necessary at all.

The objectives of this work, although less ambitious than the original intention, are nevertheless vital. Time for initial processing of experimental data will be greatly reduced. Further processing will be eased as a result and possibly extended.

II. Physical Description

During a field study the dye detection equipment was installed aboard a vessel which cruised the water area under observation. A sample was continuously pumped through the fluorometer, analyzed and the result automatically recorded on a strip chart. The water temperature and vessel locations were also noted on the tape to complete the record. The method used to keep geographical control is called "dead reckoning", i.e., traveling from one known fixed point to another, at a fixed speed along a straight line. Although simple, it is quite effective. The fluorometer was equipped with optical filters to eliminate all wavelengths except those specific for detection of the particular dye being used, e.g. Rhodamine B. The intensity of light was measured. As the light passed through the sample, its wavelength changed, since fluorescent dye has the property of changing the wavelength of light coming through it, in proportion to the concentration and temperature.

The amount of light passing through the sample was determined by manually selecting one of four aperture settings which were used so that a large range of concentrations could be monitored. The

fluorometer readings for a given scale were nearly linear with respect to concentration.

The temperature of the water sample, the fluorometer scale, the time and geographic location of the vessel were noted by hand on the chart as it moved at fixed rate with time.

Figure 1 shows an actual fluorometer tape. Note the change in scale which was made manually to enable the user to stay within the limits of the fluorometer.

It was not necessary to read the paper tape at small equally-spaced intervals. Readings at change of slope points, as shown in Figure 1 were sufficient. Slight smoothing of the fluorometer output may be effected at this stage. However, it should be realized that a procedure such as this will affect the short periods of the response function.

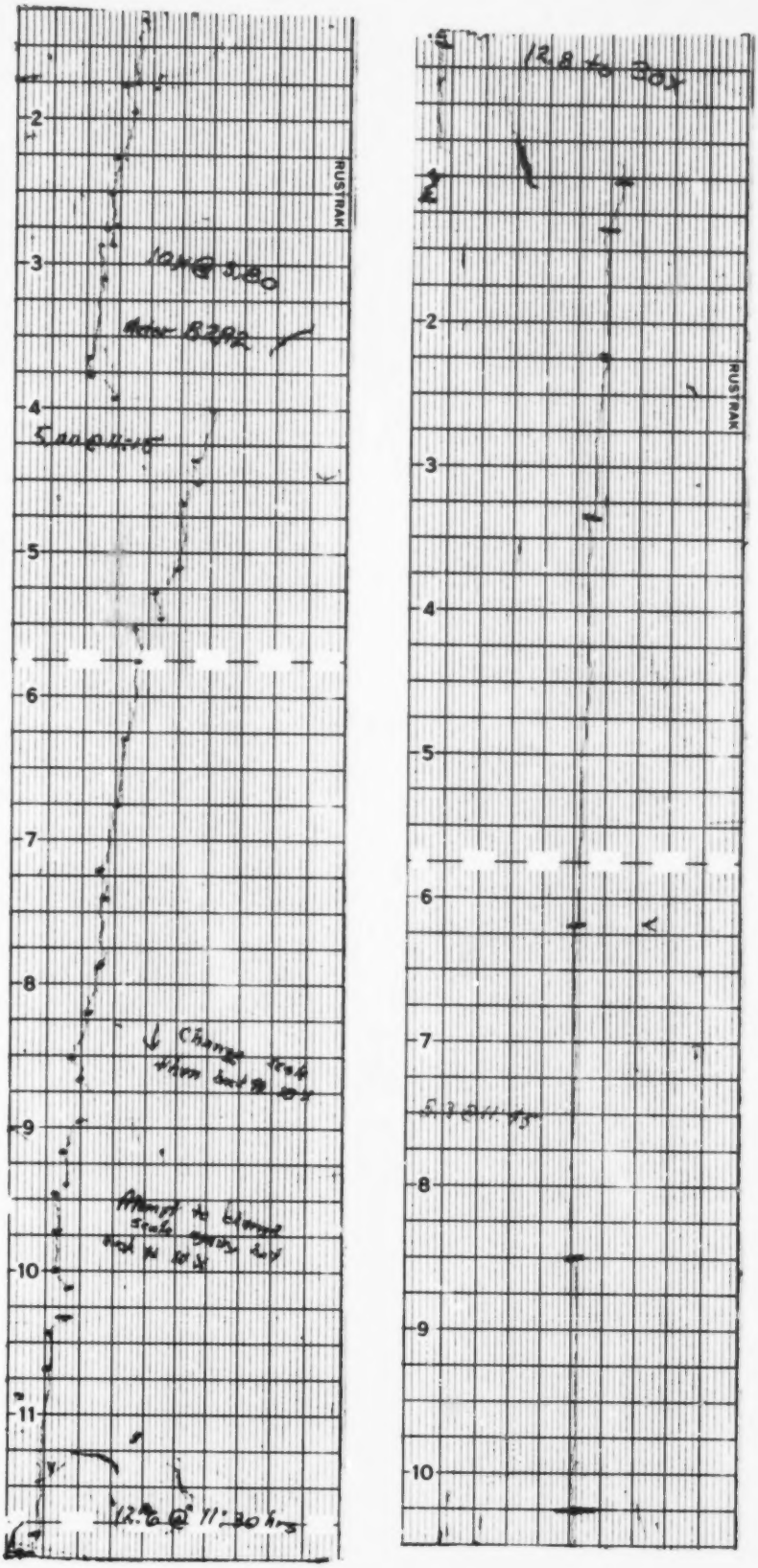

Figure 1. Sample fluorometer tape.

III. Data Preparation

A. Fluorometer calibration cards

Data preparation begins with the calibration of a fluorometer meter for each scale.

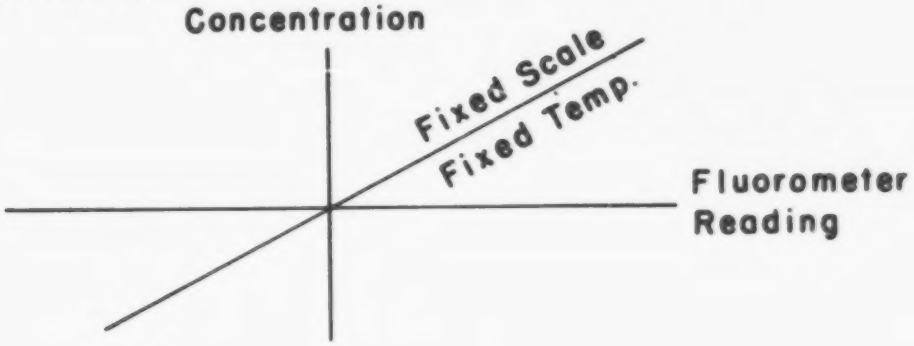

Fig. 2. Calibration line.

The slope of the calibration line as shown in the figure above (Figure 2) is determined by laboratory calibration. The fluorometer does not measure absolute concentration. Therefore, the intercept need not be zero.

In the field, a small change in the intercept may be introduced in order to make the observed background readings correspond to zero concentration. Thus, we can compensate for any natural fluorescence found in the field as long as it is constant and ubiquitous.

How do we determine the fluorometer calibration for another temperature? The slope is determined by exponential interpolation:

Slope at temperature T = slope at temperature. (T_{given}). EXP (.0117 $[T - T_{given}]$) where the laboratory calibration is taken at temperature T_{given} for a given scale.

The intercept at temperature T is determined by linear interpolation from intercepts at two temperatures TLOW and THIGH.

We are now ready to punch the calibration data on cards.

The first calibration card (lead card) for a particular meter gives the number of scales for that meter (in column 3 or 4) and the meter number (in column 15-17).

For each scale, a special scale card is punched in the following format:

Program Symbol	Definition	Column	
		1	skip
K	Scale number	2-3	I2
TLOW	Low temperature	4-7	F4.0
DELT	Difference between high and low temperature	8-11	F4.0
ME	Meter number of fluorometer	12-15	I4
CINI(K)	Intercept of the concentration line for scale K at temperature TLOW	16-22	F7.3
CIND(K)	Difference between above and intercept of the concentration line for scale K at temperature THIGH	23-29	F7.3
CSLI(K)	Slope of the concentration line for scale K at temperature TLOW	30-37	F8.3

I4 in the Fortran programming language means an integer field of four columns. F7.3 means a decimal number field of seven columns. If no decimal is punched in the card, three decimals will be assumed.

It should be noted that the number of these scale cards must be exactly the number announced in Columns 3 and 4 of the lead card.

B. Data Cards

Each data point of the fluorometer tape yields one card in the following basic format.

Fortran Symbol	Definition	Columns	Format
	(F in Column 1)	1	
Day	Time of observation	2-3	F2.0
		4	SKIP
Hour		5-6	F2.0
Minutes		7-8	F2.0
		9	SKIP
X	Geographical location	10-14	F5.0
		15	SKIP
Y		16-20	F5.0
		21	SKIP
Z		22-26	F5.0
		27	SKIP
Feet	Tape length in feet + tenths of inches	28-29	F2.0
Inches		30-32	F3.0
		33	SKIP
FR	Fluorometer reading	34-36	F3.0
		37	SKIP
LSCALE	Scale of reading	38-39	I2
TEMP	Temperature at point	40-42	F3.0
		43-61	SKIP
SH	Release time	62-63	F2.0
SM	Release location	64-65	F2.0
		66-72	SKIP
Idc	Identification card number	63-80	A8

Tape length and fluorometer reading must be punched on all cards. Time and geographical location are punched if available; otherwise corresponding columns are left blank. It will be assumed that missing values of geographical location will be linearly interpolated from the tape length. Similarly, missing time values will be interpolated by means of the tape length.

A minor difficulty results from the inability of the Fortran compiler to distinguish between blank and zero fields. Thus, zero values for time, fluorometer readings, and geographic locations must be avoided at all costs, since the computer would disregard them, and would interpolate from them using non-zero (or blank) values on either side. True zero must be replaced by values very close to zero (e.g., .0001).

C. Preparation of the master tape

We are now ready to assemble the basic card deck which is made up of the calibration cards and data cards arranged in a special way.

The basic card unit is a group. We define a group to be a sequence of less than 500 F cards (fluorometer reading) in which the first and last are complete, i.e., no time or geographical locations are missing on either card. The data cards of a group are preceded by a set of calibration cards for the particular meter involved. These in turn are preceded by a lead card telling how many calibration scale cards are expected. An end of file terminates a group. A double end of file follows the last group.

If consecutive groups employ the same fluorometer meter, the calibration cards may be omitted in succeeding graphs. However, the lead card can never be omitted. When the calibration cards are omitted, zero must be punched in the required columns to tally with the number of scale cards to follow.

The tape composed of the preceding groups of cards in the order just described will be the input tape for the preliminary program.

IV. Preliminary Program

We are now ready for the preliminary processing. This has a threefold purpose.

First, various identifications, units, etc. are prepared as the data cards for this program. These cards are in a special format as follows:

		IX	Column
	Card 1		
KAX	The number of groups to be processed	I2 IX	2-3
ID	An eight character dye dam identification	A8 IX	5-12
LABEL	A 64 character job identification	8A8	14-77
	Card 2	4X	
LABZ	Name of the depth unit of length	A8 IX	5-12
LABX	Name of horizontal unit of length	4A8	14-45
LABY	Name of lateral unit of length	4A8	46-77
	Card 3		
LABC	Concentration unit	3A8	1-24
LABP	Punched - percent concentration	3A8	15-48
LABWP	Punched - percent mass	3A8	49-72
	Card 4		
LERDA	Release date	A-8	1-8
LERTI	Release time	A-8	9-16
LERX	Release X location	A-8	17-24
LERY	Release Y location	A-8	25-32
LERZ	Release Z location	A-8	33-40

Next, tape lengths and fluorometer readings were converted to time and concentrations in parts per billion respectively. The missing geographical values were determined by interpolation.

Last, the results just computed were written and saved on a binary tape for future use. The computer could read such tape rapidly. It did not have to waste time decoding the binary coded decimal format of the original cards.

The detailed logic of this program is as follows: At the start, the number of groups and salient identifications were read in from cards and saved on the binary output tape. The sequence for each group is: notation of the number of scale cards (records on tape); the reading in of succeeding cards; conversion of tape length from feet to inches; computation by means of the scale cards of concentration noting the current temperature and scale. This cycle continues until an end of file is reached. Physical time is then computed for all points from the tape lengths and tape lengths having served their sole purpose (to determine time) are discarded. Missing geographical locations in X, Y, and Z are interpolated using physical time. The number of data points in the group followed by time, concentration, and XYZ location for each such data point, are written on the binary output tape. A detailed printed output of the group suitable for publication is now written on tape for eventual printing. This completes the processing of a data group. The preliminary program concludes after the required number of groups have been processed.

Due to human error, the above printout yielded some strange results. Negative concentrations, impossible geographic locations, and backward time seem to be the order of the day. All of these ambiguities

were studied carefully. Errors were found, cards corrected, and the entire computer program repeated.

The incorrect punching of a letter in a numerical field is found to be particularly disconcerting since the monitor system, under whose aegis the program was being run, unceremoniously terminated the programs precluding the opportunity of finding additional preliminary errors past this point without another run.

To remedy this difficulty, one version of the program neglected the binary tape. It read in the data in a special buffer as if it were a Hollerith field. It checked each required column (2-40) for permissible symbols, numerical digits, a minus sign, a decimal point, and a blank. If this special test was passed, the program continued as before. However, instead of the data being read from a card, it was decoded from the buffer area. If the test failed, the original card was punched out, printed, and the program continued without the data from this card. The absence of these data may result in gibberish for the remainder of the group. However, this phenomenon was easily recognized and corrected in the next run. In the meantime, preliminary results were produced for the ensuing groups.

It should be noted that this revised program does not guarantee to get results for all groups. It only bypasses errors in the data cards. However, an error in the scale cards, the wrong number of scale cards, the omission of an end of file between groups, or an end of file erroneously placed within a group will nullify even this amended program and processing will be discontinued at that point.

Another version of the preliminary programs creates the binary

tape without the detailed printing.

In practice, we start with the almost foolproof version, and progress to the standard version. If at this stage another run is needed, a printout might not be deemed necessary and the abbreviated version may be indicated.

Since the binary tapes cannot be printed without special printing programs, a special scanning program has been written to identify the tape and print upper and lower bounds in time, geographic location, and concentration for all groups. This information eases the task of data preparation for the remaining programs.

The binary output formed in this program was used as input for all further programs.

V. Data Presentation Programs

The concentration at point X, Y, Z at time T may be thought of as a function of four dimensions:

$$C = F(X, Y, Z, T)$$

The purpose of these programs is to study and exhibit the salient properties of one and two dimensional sections of this surface.

All of these programs study one particular subclass of data points. For example, program TYZ studies all points whose Y (lateral position), Z (depth), and time are fixed within tolerances, and where X (longitudinal position) is between two prescribed limits, e.g., from XMIN to XMAX.

The binary tape formed during the preliminary program was used in all of these programs. Each group on the tape was searched for admissible data. It is interesting to watch the computer execution

of these programs. The binary tape moves spasmodically. A data group is read into the memory. In two or three seconds it has been searched for admissible points, and the tape moves again. After the last group is processed, the tape automatically rewinds, as pertinent graphs and tables are written on the output tape. Before long the binary tape is off and running to execute its next assigned task.

In order to speed the running of the program, a vector (NP(K) was defined as follows to decide if the K^{th} data group should be searched.

If $K > 0$ the group is searched

If $K = 0$ the group is skipped

If $K < 0$ the binary tape rewinds, i.e., there are no more admissible data on the tape.

Thus, for example, if only three groups need to be searched, the binary tape will stop momentarily only three times before rewinding.

Two types of programs will now be discussed; namely one-dimensional and two-dimensional programs.

A. One-dimensional programs

Under appropriate physical conditions concentrations may be thought of as functions of a single variable. Three programs of this type will be discussed.

a) Program XYZ. Point (X, Y, Z) is fixed within tolerances. Time varying between times TMIN and TMAX.

b) Program TYZ. Time, Y and Z fixed within tolerances. X varying between XMIN and XMAX.

c) Program TXZ. Time, X and Z fixed within tolerances. Z varying between YMIN and YMAX.

a) Program XYZ

In the simplest case, the ship is anchored and concentration is maintained as a function of time at a fixed point as the dye patch crosses the sampling point.

If we desire the graph of this concentration as a function of time between two fixed points in time from TMIN to TMAX, should we graph only data points? Clearly the particular data points on the fluorometer paper tape were selected so that intermediate points could be determined by linear interpolation. Thus, all points between two consecutive data points may be graphed. The path will be linear between the two points.

Note: linear interpolation is not allowed between two successive data points if they are not consecutive; i.e., if they do not come from two consecutive points on the original fluorometer tape. As a matter of fact, the first admissible point is not graphed at all unless the very next point is also admissible. In that case, the entire linear path is drawn between the two points. Interruptions in the sequence of consecutive admissible points can result from a ship moving away from the fixed location to follow the dye patch for a while, or other causes. If the vessel returns to its original location, and thus again admissible data is yielded, the graphing begins anew.

At times non-admissible data are directly used in graphing. For example, suppose admissible data are given for 3 hours after release, 3:05, 3:15, and 3:35. If the graph ends at 3:30, the data from 3:35 are used to draw the graph from 3:15 to 3:30.

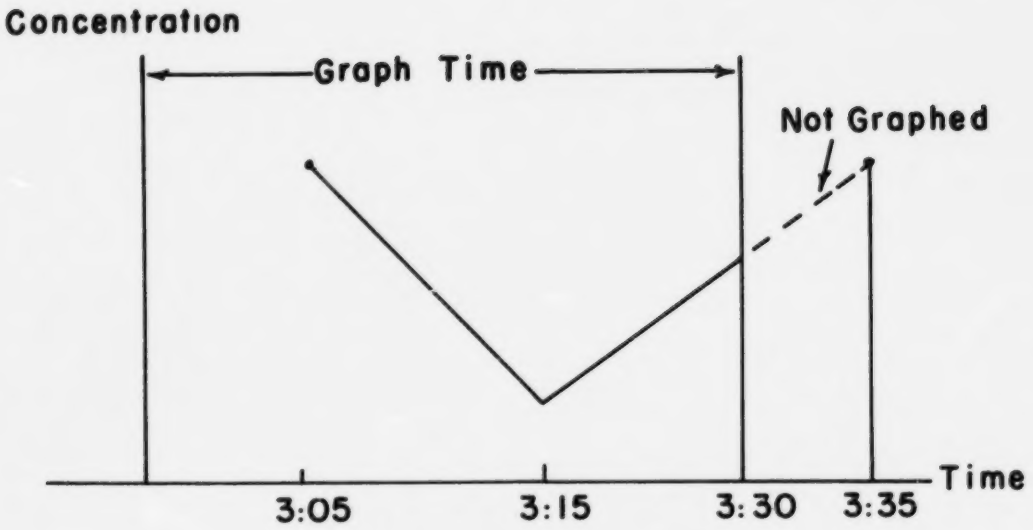

Fig. 3. Concentration vs time.

This procedure is amplified for the next program (TYZ).

This program has been written in subroutines to make it possible for novices to write the main programs.

The calling sequence for the subroutine is:

Call: XYZFIX (TMIN, TMAX, FX, FY, FZ, NgR, delc, Id)

where:

TMIN = minimum time, starting point of graph.

TMAX = maximum time, ending point of graph.

FX = Fixed, horizontal position of fixed point.

FY =Fixed lateral position of fixed point.

FZ = Fixed depth.

delc = initial concentration scale interval

delc is the initial guess for the concentration graphing interval . If the actual scale interval is S, the concentration graph will be labeled 0, S, 2S, 3S, ···. Initially S is taken equal to delc. If the maximum concentration is graphable (the number of intervals are not greater than 49) this scale is used. If not, S = 2 delc is tried.

If this scale still does not suffice, S = 3 delc, etc. is attempted. In this way the scale S is determined. Actually the above algorithm is not programmed, since it is easy to write an arithmetic formula for S.

NGR = The number of graphing points on the time axis. The maximum allowable number is 111.

ID = An alphabetical identification of 8 characters.

b) Program TYZ

In studying diffusion of dye in a river, a simplifying assumption is made that the concentration is a function of only one variable, the longitudinal axis taken along the direction of the river.

Although Y is fixed, possibly at midstream, and Z is fixed, possibly as Z = 0 at the surface, it is desirable to take mass into account as represented by particular dye concentration.

To accomplish this, a weight function is defined. For any point X in the river, the weight function at X is the product of the cross sectional vertical area of the river at the point X multiplied by a unit conversion factor, since units may be changed. X, for example, may be measured in hundreds of yards, Z in feet, etc.

Let dX be a small longitudinal segment of the river. Let W(X) be the weight factor at X. Let C(X) be the concentration of the dye at X measured in parts per billion.

No matter what units are used for X, Y, Z, the expression (W[X])(dX) represents the volume of the segment and the product of C(X)*W(X)*dX represents the mass of the dye in pounds within the segment, assuming a uniform mixture of the dye.

In any particular section, e.g. between X_n and X_{n+1} the weight function is given by

$$W(X) = A + B \sin(WT + \phi)$$

where:

A is the mean tidal height of the water cross-sectional volume per dX times a units conversion factor,

B is one-half the cross-sectional value per dX change caused by the tide multiplied by a units conversion change,

T is time measured in hours from release,

$W = \frac{2\pi}{12.42}$

ϕ = a phase angle introduced to simulate the mathematical tide with the actual tide at the release point and at release time.

For every pair of graphable consecutive data points, the following table is printed:

ΔX, C, MASS, TOTAL MASS TO POINT

Graphing proceeds as in the XYZ case. This case is more complicated than XYZ. In XYZ time, the independent variable simply increases steadily. However, in TYZ, the values of X, the independent variable, may grow larger, then smaller, then larger again. The boat may pass the same point several times during the allowed time interval, thus giving a multivalued concentration. In other words, the concentration function at a point may be multivalued.

Because of graphing difficulties, it was decided not to consider multivalued functions and the concentrations were averaged by the following technique: At the start there are no more than 111 memory locations to correspond to concentrations at points X from minimum X to maximum X, divided into a histogram of 111 points. These locations are initially zero. Required concentration totals are amassed there.

In order to discuss the algorithm used to process the data of each group, the following definition is needed:

A FAD (fixed admissible) point is a point satisfying the requirements for time Y and Z (within tolerances), but it is not necessary that the condition for the independent varaible X to be between XMIN and XMAX. Thus, every admissible point is also a FAD point. Conversely, however, not every FAD point is admissible.

The following algorithm is applied to each sequence of consecutive FAD points within a group. At the start of a group no FAD points have been processed. As soon as the first one appears, we note whether it is in range (i.e, X between XMIN and XMAX) i.e. admissible or whether it is on the left (X < XMIN) or on the right (X > XMAX). Now the next point is checked. If it is a FAD point, one of the following processes takes place, depending upon the case.

1) If both points are indeed admissible points (not merely FAD) each point is translated to a graphing point print from 1 to (at most) 111 points. Concentrations are interpolated for all points in between, and concentration totals are amassed at the respective memory locations.

2) If one point is inside (i.e. admissible) and the other outside (either on left or right), concentrations are found for both points. Concentrations are interpolated and amassed for all points between the two that fall inside the range of X.

3) If both points are outside the range of X on the same side, no amassing of concentrations takes place.

4) If one point is outside on the left and the other outside on the right concentrations at all 111 points are determined. (This case is most unlikely. It must be considered, however, for completeness.)

In all cases, the second FAD point becomes the first FAD point for the next pair. If at any time, the next point is not a FAD point, or if the group is terminated, the sequence is completed. Searching continues until the next sequences of FAD points are encountered and they are processed as before. After all the required searching is completed, concentration averages are found at each of the 111 points.

These concentrations are now changed to masses of dye by the weight function. These dye masses are summed (sub-totaled) so that the percent of the total mass up to any point can be found.

Graphs of unweighted concentration versus X, and percent mass of dye versus X are drawn. The latter is convenient as we can visually see the centroid of the dye. By combining a sequence of these graphs, we can see where the dye is actually moving.

The calling sequence for this subroutine is:

Call TYZFIX (FT, TOL, FY, FZ, NW, NgK, delc, where

TOL is tolerance for fixed time,

FX is the fixed X,

FY is the fixed Y,

FZ is the fixed Z ,

NW is the number of X intervals needed to define the weight function,

NGR is the number of graphing points, not greater than 111. If preceded by a minus sign, the graph will be drawn from XMAX on the left to XMIN on the right.

delc - defined as before in XYZ,

ID - an eight-character identification.

The weight constants are read in by a data statement defining a vector XW as follows:

XW(1) = minimum X under consideration,

XW(2) = A for first interval,

XW(3) = B for first interval,

XW(4) = X value for end of first interval and beginning of second,

XW(5) = A for second interval,

XW(6) = B for second interval,

XW(7) = X value for end of second interval and beginning of third interval

---

XW(3*NW-2) = X value of beginning of last interval,

XW(3*NW-1) = A for last interval,

XW(3*NW) = B for last interval,

XW(3*NW + 1) = end of last interval,

XW(3*NW + 2) = W as defined for weight function,

XW(3*NW + 3) = ϕ as defined for weight function.

Care must be taken to insure that XW(1) is small enough, and that XW(3*NW + 1) is large enough to insure that the weight function will be defined for all X in the data.

c) Program TXZ

Program TXZ is analogous to TYZ. Here the river flows in the Y direction. This routine is especially helpful for tributaries off the main stream.

B. Two-dimensional programs

It is desired to exhibit the dye concentrations in some two-dimensional space such as a bay or an estuary.

How can this third dimension concentration be shown on two-dimensional paper by means of a digital computer graph? Suppose we want to exhibit a particular concentration at a particular point (X, Y). How is the X graphed? We find the niche into which X falls in a histogram or (possibly) 111 points from XMIN to XMAX. Similarly we graph Y by finding into which class Y falls in a histogram of (possibly) 50 points from YMIN to YMAX. In exactly the same manner, one may find that the concentration falls in a histogram of (possibly) 35 points from CMIN = 0 to CMAX. We find the X position by marking off the correct number on a horizontal scale. We find the Y position by marking off the appropriate class number in the vertical direction. At that combined (X, Y) position we exhibit the required concentration by printing a particular symbol. We define a sequence of (possibly) 35 symbols, e.g., blank, digits 1-9, followed by letters of the alphabet A-Z, omitting O. Thus, instead of counting to the right to find X or counting up to find Y, we count in the sequence until we find the appropriate printing symbol. The scale is given by writing the value of each concentration symbol at the top of the graph.

It was decided to allow the computer to draw a map delineating the two dimensional area. This was accomplished by reading in the needed boundary points together with the boundary symbol, e.g., an *. During the processing, any points are disregarded if out of range of a given graph.

Labeling of land masses can be accomplished in a similar manner. The true X and Y position of a particular symbol is given together with the symbol. Due to errors inherent in histograms, symbols defined to be equally spaced may not necessarily appear so. Labeling over water areas is risky as the labeling characters may be written over if any concentrations appear at the label position. These values are punched on cards, six symbols to a card, in the following format:

	Column
X position of first symbol	2-6
symbol	7
Y position of first symbol	8-12
X position of second symbol	14-18
symbol	19
Y position of second symbol	20-24
X position of third symbol	26-30
symbol	31
Y position of third symbol	32-36
X position of fourth symbol	38-42
symbol	43
Y position of fourth symbol	44-48
X position of fifth symbol	50-54
symbol	55
Y position of fifth symbol	56-60
X position of sixth symbol	62-66
symbol	67
Y position of sixth symbol	68-72

The preceding format can be written succinctly in a single line by means of the Fortran language.

6(1X, F5.1, A1, F5.1)

These cards are written on tape. During the execution of the program, the tape is read in each time a graph is called for.

Another graph is added, namely the path of the ship as it traverses the dye patch. Every datum is represented by a letter of the alphabet, beginning with A. After Z the alphabet repeats itself. See Figure 13.

The calling sequence for this routine is:

Call TZFIX (FT, TOL, FZ, NLINE, XMIN, XMAX, NgR, YMIN, YMAX, delc, ID)

where:

FT = fixed time

TOL = time tolerance, i.e., TMIN = FT - TOL and TMAX = FT + TOL

FZ = fixed Z

NLINE = number of points in the boundary or label--must be zero if these points are not desired

XMIN = the minimum of X

XMAX = the maximum of X

NGR = the number of graphing points in the X direction. It must be

YMIN = minimum of Y

YMAX = maximum of Y

delc = the difference between any two consecutive concentration symbols. The maximum concentration is assumed to be 34.5 delc. A concentration higher than the maximum will be graphed at the maximum.

ID = an eight character identification.

A valid criticism of this program is that each point when graphed destroys what was there previously. This is done to conserve both computer memory and computer time. The graph is actually written in the memory as the valid points are found. This is the reason that the scale must be known in advance.

This program can be modified and specialized to fit more particular needs, e.g., the computer can interpolate between data points (as in the one-dimensional case). The data can also be completely contoured following standard techniques developed by the Weather Bureau. In this case the graphing symbols represent the path of the level curves of the dye concentration surface.

VI. Further Research

This report can be used for generalizations in various directions.

A) Other navigational systems

Dead reckoning, the crude manual method of keeping track of geographical location described herein, can be refined in various ways. An inertial guidance system with automatic read-out on magnetic tape is ideal. Such systems exist and are in operation on many naval ships. Unfortunately, they are too expensive for oceanography research ships.

The RATAN system of navigation is made available in certain areas by the Coast Guard. This is a televised radar scan which shows the shorelines, all navigational aids, and the vessel location. Thus the ship can see itself on its own television screen. This screen together with a clock can be photographed at any convenient interval.

There is also a system of navigation which allows the ship to receive telemetric directions from two fixed beacons. Since the distance between these beacons is known, geographical location can be computed by triangulation. The telemetric direction and a clock can be photographed at convenient intervals. ‡

A navigational method is being developed at New York University based on the Doppler shift. Richard L. Reinert and Gerard J. McNally of the Department of Meteorology and Oceanography of New York University, have described this method in a report† from which we quote.

> "The R. V. KYMA is equipped with doppler sonar which measures the speed of the ship relative to the bottom. This

† "On the Use of a Tape Recording System in Dye Diffusion Studies."
‡In use by Richardson at Marine Laboratory in University of Miami.

signal is integrated to give distance traveled and both are displayed on the front panel of the doppler indicator unit. Using the doppler sonar, the location of the vessel is determined relative to the hand buoys while crossing the dye plume and continuously sampling the concentration. The doppler readings, in yards traveled, are recorded by hand on the margin of the fluorometer record."

Any of the above systems is easily made compatible with the present program package. Only the preliminary program needs to be revised in each case. In any case, the binary tape output of the revised preliminary program is identical to the original. Remaining programs operate on this tape and therefore remain valid without revision. Of course automatic readout will physically increase the amount of data (since readings will be made at very small intervals) and slow its processing. However, a subroutine may be devised which will omit points that may be recovered with a linearity assumption.

B. Other computers

These programs have been written in Fortran 63 for a control data computer. With comparatively little effort these programs are transcribed into Fortran IV used by all large IBM computers from the 7040 to the 360. The only non-trivial problem is the IF (EOF) instruction which checks on the presence of an end of file in the previously read tape list, since this instruction is not allowed in IBM Fortran. There are two ways to cope with this. A machine language subroutine can be written to cover this omission, or else the deck arrangement can be modified allowing a blank card between groups instead of an end of file. The remaining revisions, though trivial, are pregnant with error possibilities. Special minor changes are necessary n ot only for different computers but for the same computer under different Fortran versions.

No effort was made in this study to conserve computer time by writing machine language subroutines. A case in point is the routine INSIDEF. The repeated use of this subroutine ascertains whether each point is between the correct bounds of time and geographical location, thus determining its admissibility. A machine language version of this routine would speed up the running time of the program.

C. Analogue plots

Analogue plots to replace the digital plots described in this report using, for instance, the CALCOM plotter, are readily written. Resolution and graph quality will be very much higher.

These graphs are drawn one point at a time. Thus printing is slow and relatively expensive. This is the price one must pay for the increase in resolution, and the general improvement of the caliber of the graphs.

D. Other programs

It is hoped that these programs will have their baptism of fire in the field and be applied repeatedly. The significance of this work lies not in its potential graphs, but in its potential in bringing to the scientist the salient realization that every point in the dye field has been computerized and is at his disposal. He now has a powerful tool which can be used to test any hypothesis that can be dreamed up by his fertile mind. It is hoped that this report will be remembered not for the programs that have already been written, but for the programs that can be easily written because of it.

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Appendix I
Computer Results

U.S. DEPT. OF HEW. HUDSON-CHAMPLAIN PROJECT. DYE TRACER STUDY

STUDY HUDSON R RELEASED 08/03/65 AT HW SLACK RELEASED LOCATION X= .Y= .0001

X=HUNDRED YARDS NORTH OF BATTERY . Y=DISTANCE FROM MIDSTREAM (+=EAST) . Z= FT DEPTH . TIME= HOURS AFTER RELEASE

CONC.= MICROGRAMS PER LITER . TEMP=DEG.CENT. GROUP 17 OF 34 CONTAINING 373 OBSERVATIONS

N	CARD ID	T.LENGTH	FL.N.	SCALE	TEMP.	HOURS	CONC.	X	Y	Z
51	HR 7 51	10.32	16	30	25.0	11.85	.38	581.00	.00	4.00
52	HR 7 52	10.33	18	30	25.0	11.86	.44	562.10	.00	4.00
53	HR 7 53	10.40	15	30	25.0	11.89	.35	586.51	.00	4.00
54	HR 7 54	10.47	20	30	25.0	11.92	.50	590.92	.00	4.00
55	HR 7 55	10.67	33	30	25.0	12.01	.90	604.14	.00	4.00
56	HR 7 56	10.73	44	30	25.0	12.03	1.23	608.00	.00	4.00
57	HR 7 57	10.79	49	30	25.0	12.06	1.38	610.95	.00	4.00
58	HR 7 58	10.88	52	30	25.0	12.10	1.47	615.00	.00	4.00
59	HR 7 59	11.18	39	30	25.0	12.22	1.08	627.67	.00	4.00
60	HR 7 60	11.33	53	30	25.0	12.28	1.50	634.00	.00	4.00
61	HR 7 61	11.36	50	30	25.0	12.29	1.41	635.80	.00	4.00
62	HR 7 62	11.39	56	30	25.0	12.31	1.59	638.20	.00	4.00
63	HR 7 63	11.43	80	30	25.0	12.32	2.31	640.60	.00	4.00
64	HR 7 64	11.46	84	30	25.0	12.34	2.44	643.00	.00	4.00
65	HR 7 65	11.50	84	30	25.0	12.36	2.44	646.00	.00	4.00
66	HR 7 66	11.56	77	30	25.0	12.38	2.22	650.20	.00	4.00
67	HR 7 67	11.58	77	30	25.0	12.39	2.22	652.00	.00	4.00
68	HR 7 68	11.69	48	30	25.0	12.44	1.35	659.80	.00	4.00
69	HR 7 69	11.73	32	30	25.0	12.46	.87	662.20	.00	4.00
70	HR 7 70	11.75	26	30	25.0	12.47	.69	664.00	.00	4.00
71	HR 7 71	11.83	17	30	25.0	12.50	.41	668.50	.00	4.00
72	HR 7 72	11.96	15	30	25.0	12.56	.35	675.25	.00	4.00
73	HR 7 73	11.98	18	30	25.0	12.57	.44	676.60	.00	4.00
74	HR 7 74	12.00	13	30	25.0	12.57	.29	677.50	.00	4.00
75	HR 7 75	12.10	11	30	25.0	12.62	.23	682.90	.00	4.00
76	HR 7 76	12.17	12	30	25.0	12.65	.26	686.50	.00	4.00
77	HR 7 77	12.19	10	30	25.0	12.66	.20	687.85	.00	4.00
78	HR 7 78	12.24	12	30	25.0	12.68	.26	690.55	.00	4.00
79	HR 7 79	12.25	18	30	25.0	12.68	.44	691.00	.00	4.00
80	HR 7 80	12.35	36	3	25.0	12.73	9.72	691.00	.00	4.00
81	HR 7 81	12.38	38	3	25.0	12.74	10.33	691.00	.00	4.00
82	HR 7 82	12.39	20	3	25.0	12.75	4.83	691.00	.00	4.00
83	HR 7 83	12.43	8	3	25.0	12.77	1.17	691.00	.00	4.00
84	HR 7 84	12.44	24	10	25.0	12.77	2.33	691.00	.00	4.00
85	HR 7 85	12.46	24	10	25.0	12.78	2.33	691.00	.00	4.00
86	HR 7 86	12.47	10	10	25.0	12.78	.78	691.00	.00	4.00
87	HR 7 87	12.48	4	10	25.0	12.79	.11	691.00	.00	4.00
88	HR 7 88	12.52	20	30	25.0	12.81	.50	691.00	.00	4.00
89	HR 7 89	12.54	34	30	25.0	12.82	.93	691.00	.00	4.00
90	HR 7 90	12.55	80	30	25.0	12.82	2.31	691.00	.00	4.00
91	HR 7 91	12.56	66	30	25.0	12.82	1.89	691.00	.00	4.00
92	HR 7 92	12.57	66	30	25.0	12.83	1.89	691.00	.00	4.00
93	HR 7 93	12.58	80	30	25.0	12.84	2.31	691.00	.00	4.00
94	HR 7 94	12.60	80	30	25.0	12.84	2.31	691.00	.00	4.00
95	HR 7 95	12.63	66	10	25.0	12.85	6.99	691.00	.00	4.00
96	HR 7 96	12.64	10	3	25.0	12.86	1.78	691.00	.00	4.00
97	HR 7 97	12.68	26	10	25.0	12.88	2.56	691.00	.00	4.00
98	HR 7 98	12.77	14	30	25.0	12.92	.32	691.00	.00	4.00
99	HR 7 99	12.80	15	30	25.0	12.93	.35	691.00	.00	4.00
100	HR 7 100	12.84	34	30	25.0	12.95	.93	691.00	.00	4.00

Figure 4. Table - Preliminary Program

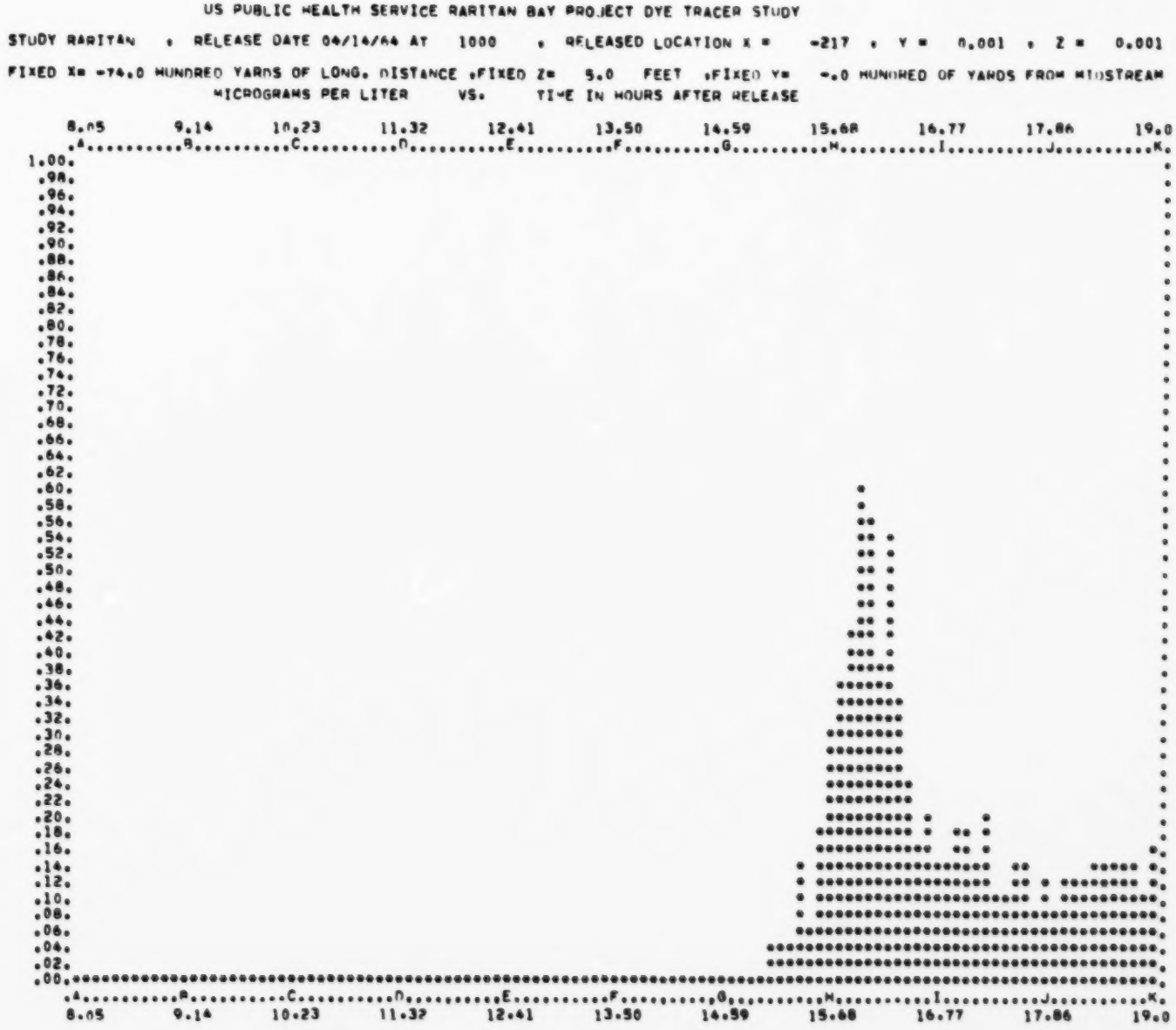

Fig. 5. Graph - Program XYZ

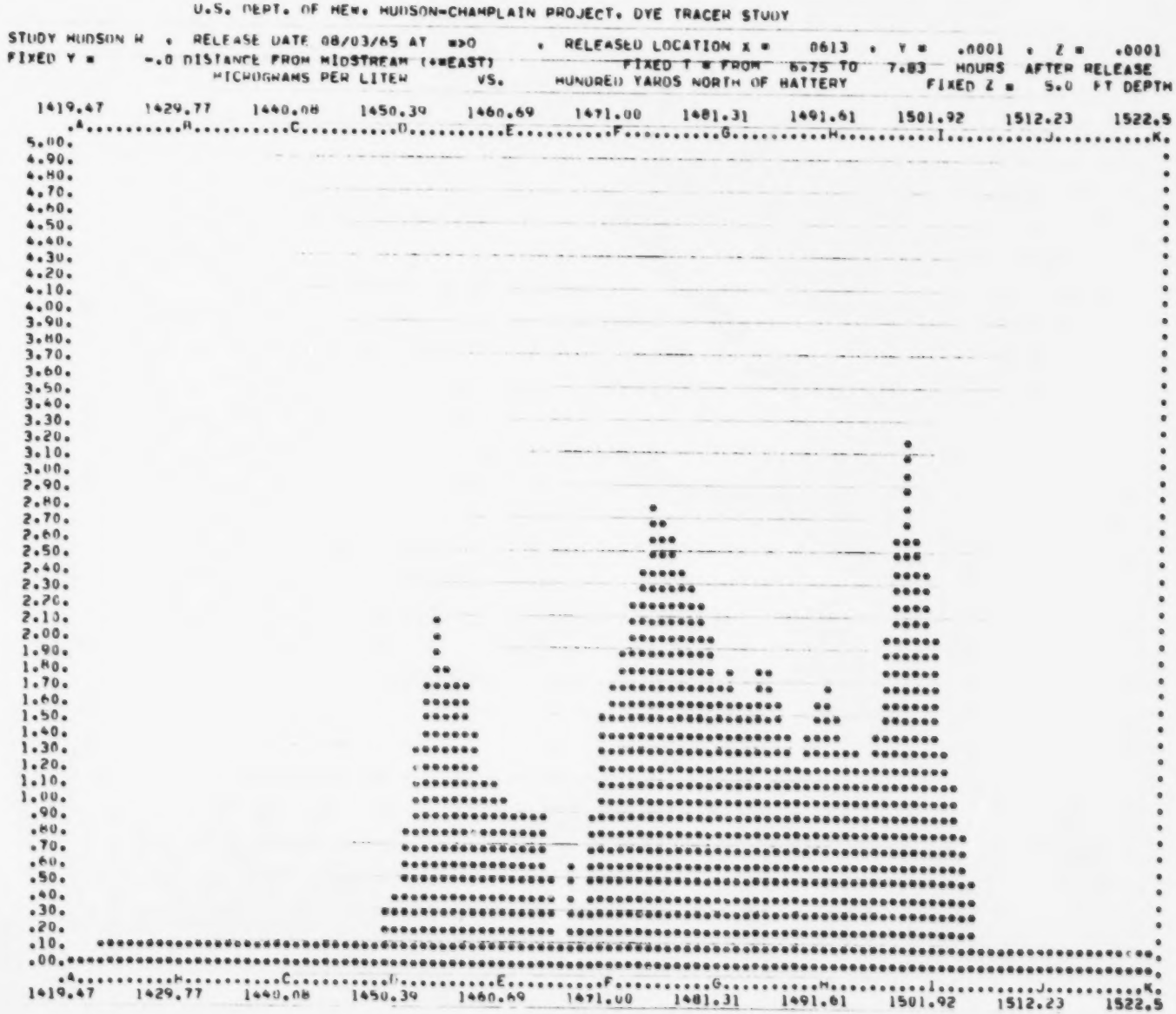

Fig. 6. Graph - Program TYZ

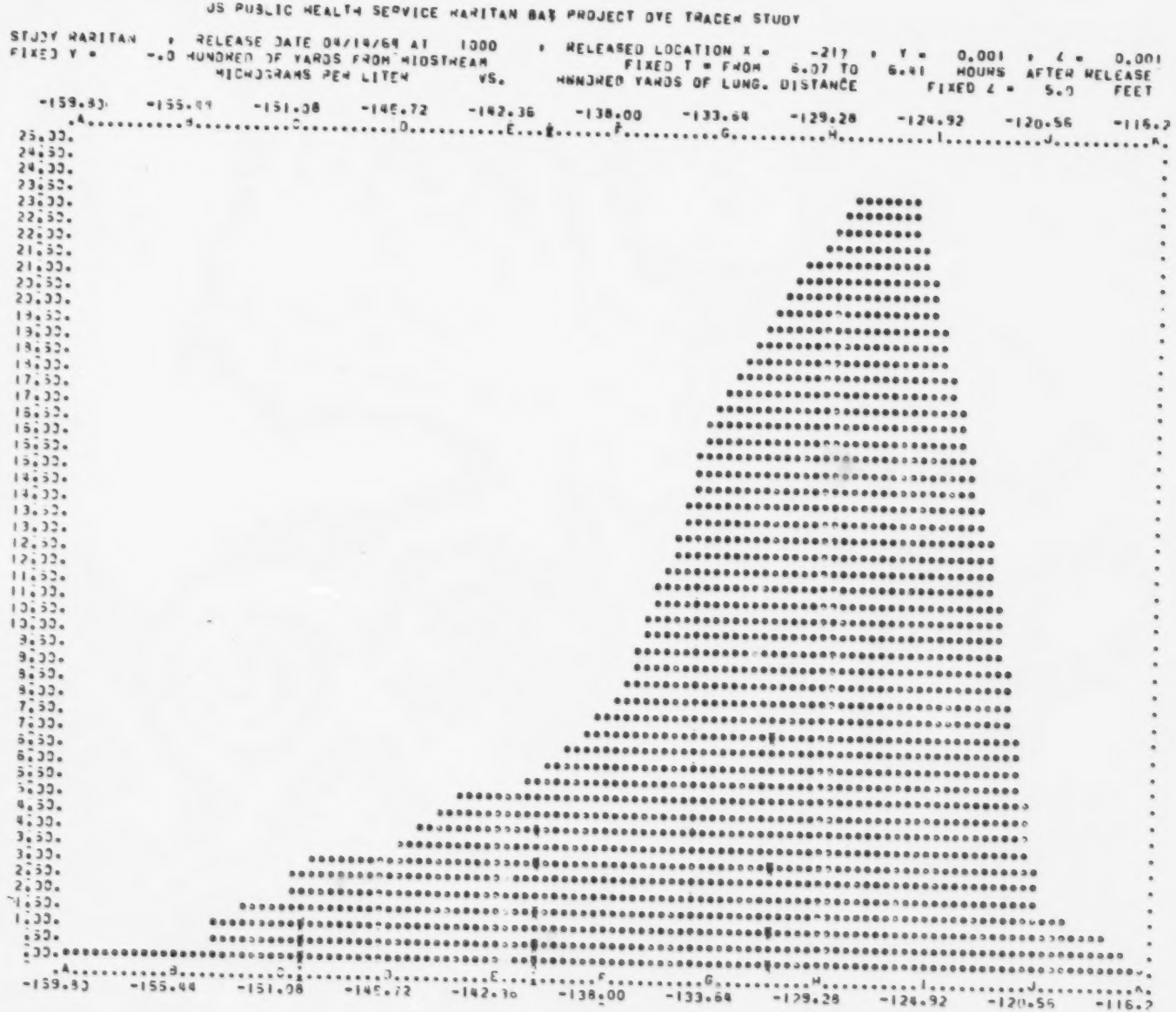

Fig. 7. Graph - Program TYZ

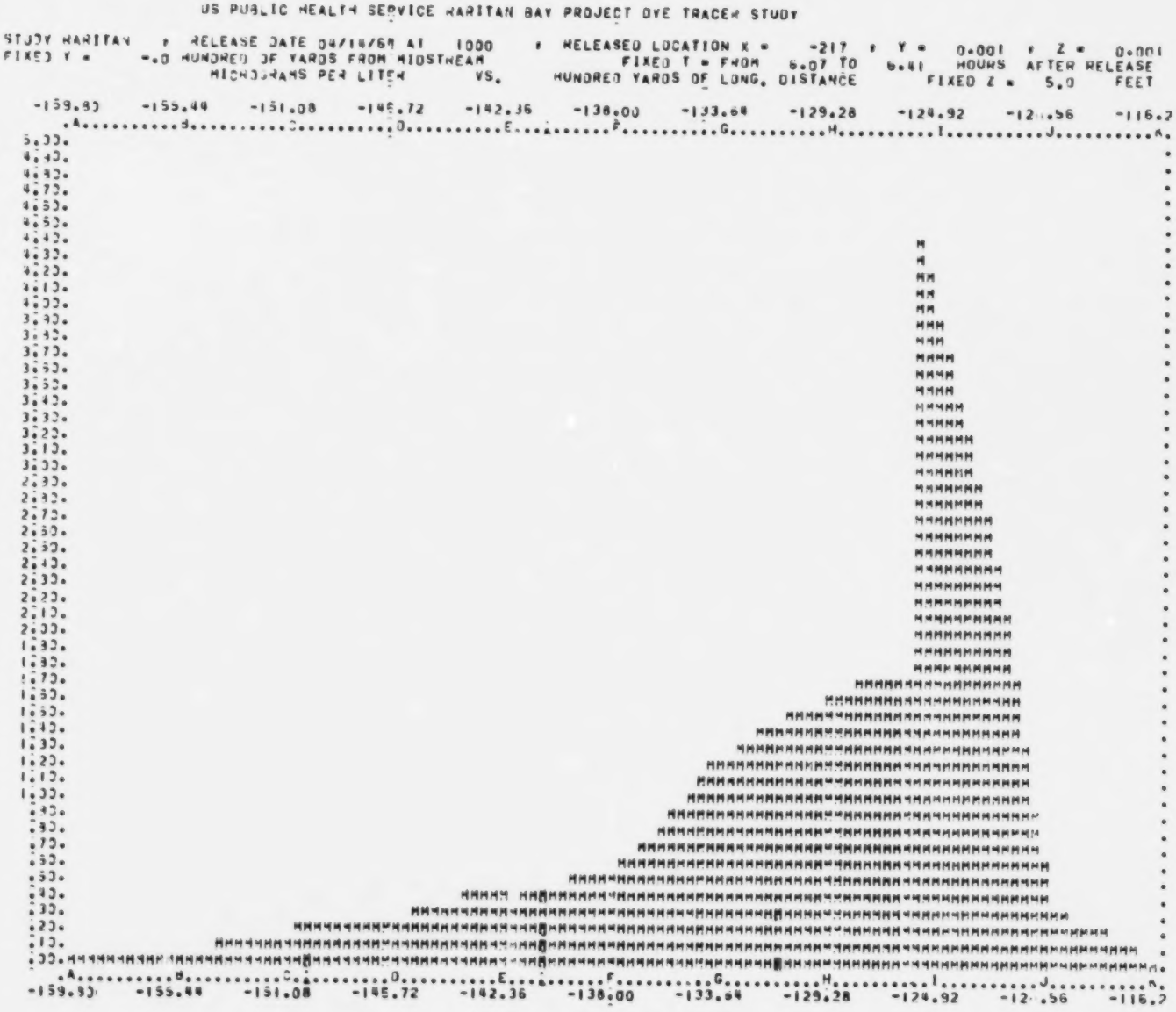

Fig. 8. Graph - Program TYZ

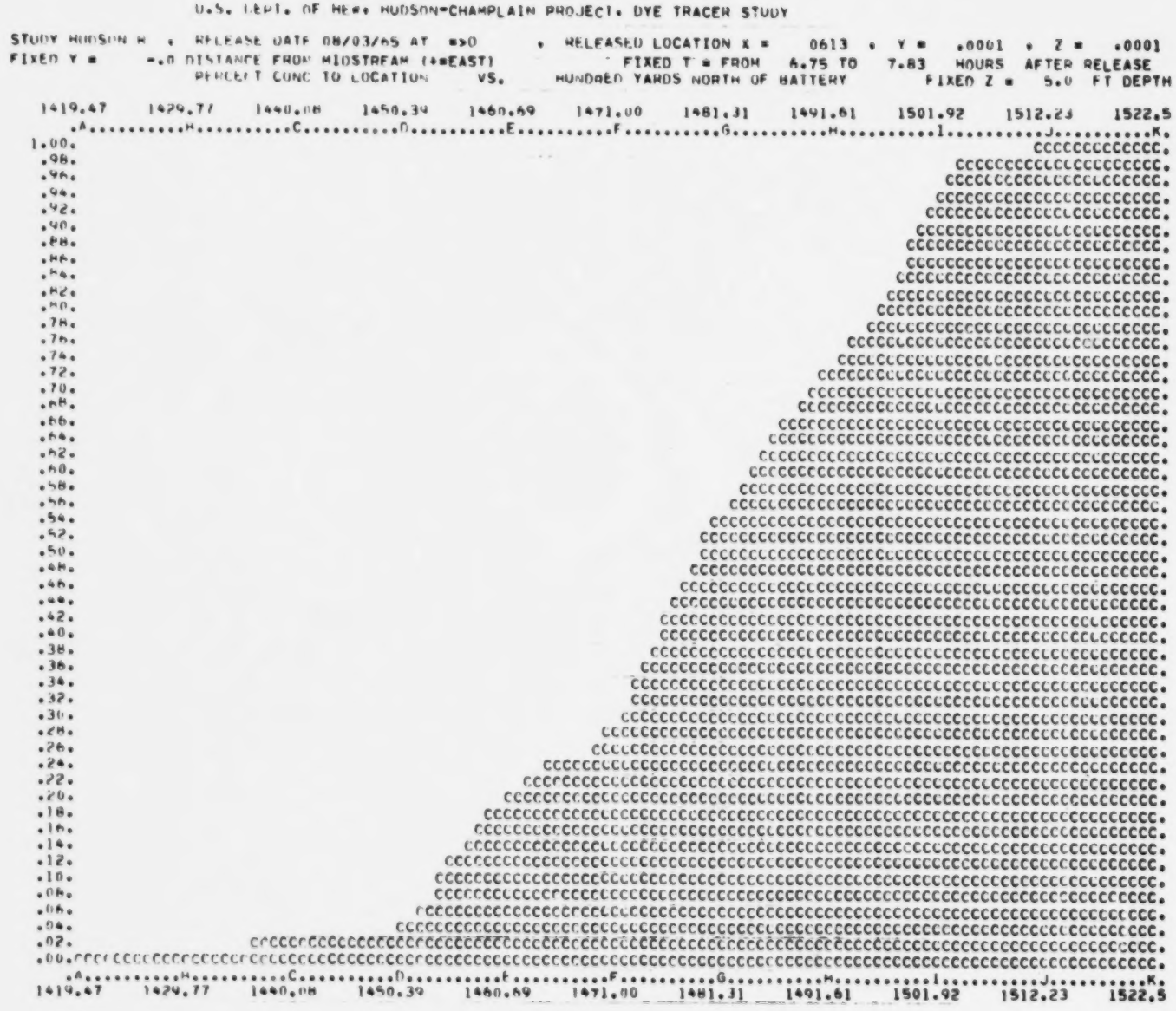

Fig. 9. Graph - Program TYZ

US PUBLIC HEALTH SERVICE RARITAN BAY PROJECT DYE TRACER STUDY
STUDY RARITAN , RELEASE DATE 08/18/69 AT 1000 , RELEASED LOCATION X = -217 , Y = 0.001 , Z = 0.001
FIXED Y = -.0 HUNDRED OF YARDS FROM MIDSTREAM FIXED T = FROM 6.07 TO 6.41 HOURS AFTER RELEASE
PERCENT MASS TO LOCATION VS. HUNDRED YARDS OF LONG. DISTANCE FIXED Z = 5.0 FEET
-159.80 -155.44 -151.08 -146.72 -142.36 -138.00 -133.64 -129.28 -124.92 -120.56 -116.2
-159.80 -155.44 -151.08 -146.72 -142.36 -138.00 -133.64 -129.28 -124.92

Fig. 10. Graph - Program TYZ

US PUBLIC HEALTH SERVICE RARITAN BAY PROJECT DYE TRACER STUDY

STUDY RARITAN , RELEASE DATE 08/14/64 AT 1000 , RELEASED LOCATION X = -217 , Y = 0.001 , Z = 0.001

FIXED Y = -.0 HUNDRED OF YARDS FROM MIDSTREAM MICROGRAMS PER LITER VS. FIXED T = FROM 6.07 TO 6.81 HOURS AFTER RELEASE HUNDRED YARDS OF LONG. DISTANCE FIXED Z = 5.0 FEET

N			FROM	TO	DELX	AVER C	AV. J	CDELX	MASS	SUM C	SUM MASS
1	111	111	-115.3469	-116.0000	.3469	.1881	.1880	.0653	.0652	.0653	.0652
2	107	111	-117.6939	-116.3469	1.3469	1.0542	.1880	1.4200	.2532	1.4852	.3184
3	105	107	-118.7041	-117.6939	1.0102	2.2332	.1880	2.2569	.1899	3.7412	.5084
4	103	105	-119.3776	-118.7041	.6735	2.9111	.1880	1.9806	.1298	5.7018	.6380
5	102	103	-119.7143	-119.3776	.3367	3.8265	.1880	1.1875	.0633	6.8893	.6983
6	101	102	-119.9762	-119.7143	.2619	3.9849	.1880	1.0037	.0492	7.9329	.7475
7	100	101	-120.5000	-119.9762	.5238	5.8661	.1880	3.0727	.0985	11.0057	.8460
8	35	100	-122.5952	-120.5000	2.0952	20.0718	.1880	82.0552	.3439	93.0608	1.2899
9	37	35	-125.7341	-122.5952	3.1429	45.9910	.1880	144.5430	.5804	197.6039	1.8704
10	36	37	-126.0000	-125.7381	.2619	54.3868	.1295	15.5537	.0334	213.1575	1.8647
11	31	36	-127.8947	-126.0000	1.8947	59.0439	.0710	111.8727	.1345	325.0303	1.9993
12	73	31	-131.2105	-127.8947	3.3158	54.8345	.0710	181.8196	.2354	506.8498	2.2347
13	55	73	-130.5263	-131.2105	3.3159	45.3355	.0710	150.3231	.2354	657.1730	2.4701
14	54	55	-135.0000	-130.5263	.4737	37.5456	.0710	17.8037	.0336	674.9767	2.5037
15	56	54	-137.2857	-135.0000	2.2857	28.4139	.0710	64.9860	.1523	739.9227	2.6560
16	54	56	-138.6571	-137.2857	1.3714	19.3750	.0710	26.5715	.0474	766.4942	2.7034
17	56	54	-141.8571	-138.6571	3.2000	14.8102	.0710	47.3427	.2272	813.8869	2.9306
18	52	56	-143.6857	-141.8571	1.8286	12.7272	.0710	23.2726	.1298	837.1595	3.0604
19	35	42	-146.4286	-143.6857	2.7429	10.7401	.0710	29.4985	.1944	866.6580	3.2548
20	26	35	-150.0857	-146.4286	3.6571	7.8573	.0710	28.7351	.2597	895.3931	3.5145
21	23	26	-151.0000	-150.0857	.9143	6.4684	.0710	5.9103	.0549	901.2035	3.5694
22	23	23	-151.0000	-151.0000	0	3.6464	.0710	0	0	901.2035	3.5694
23	19	23	-152.8519	-151.0000	1.8519	3.4358	.0710	6.3626	.1315	907.6261	3.7713
24	16	19	-153.3630	-152.8519	1.1111	2.8842	.0710	3.2046	.0749	910.8307	3.8502

Fig. 11. Table - Program TYZ

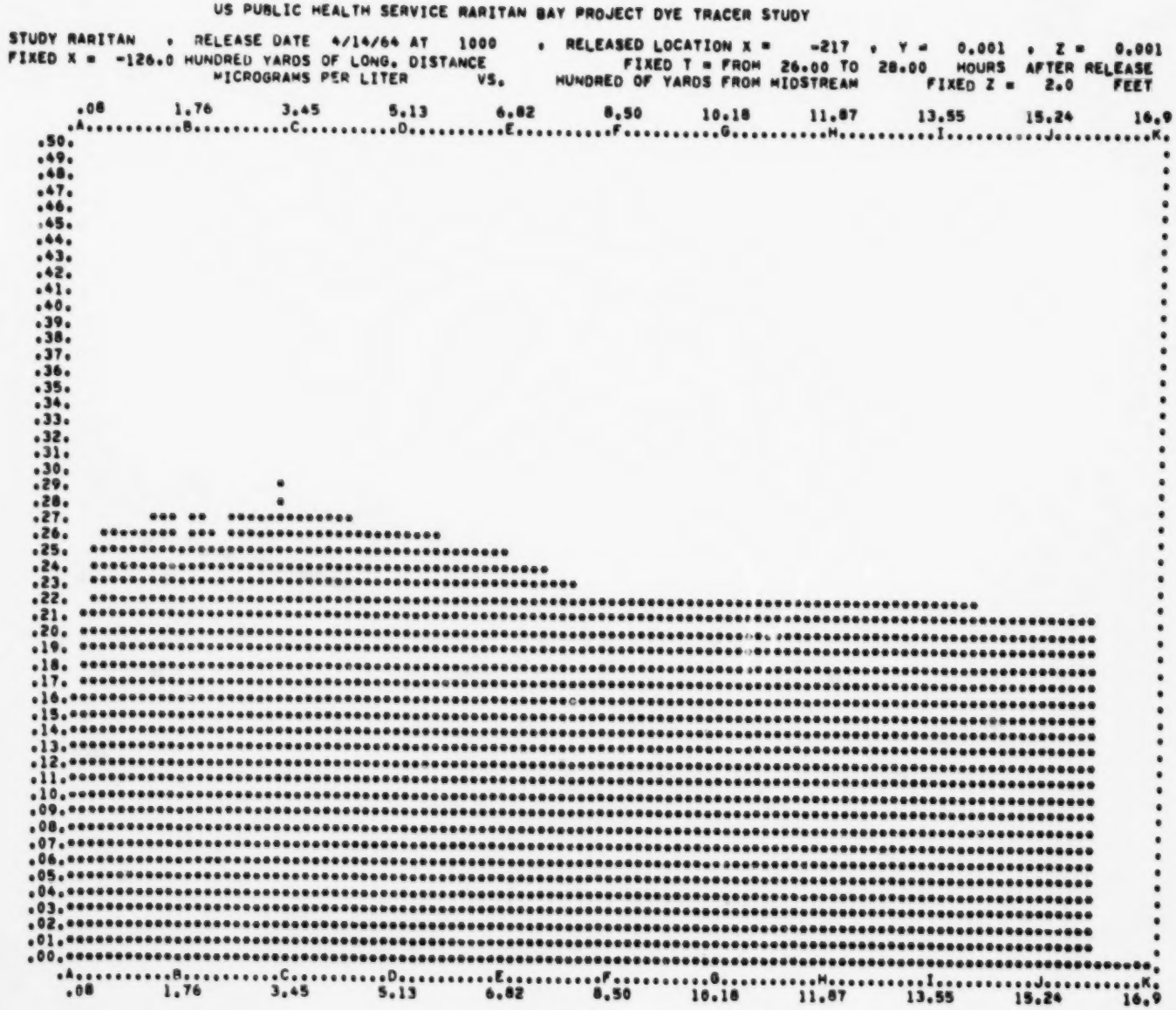

Fig. 12. Graph - Program TXZ

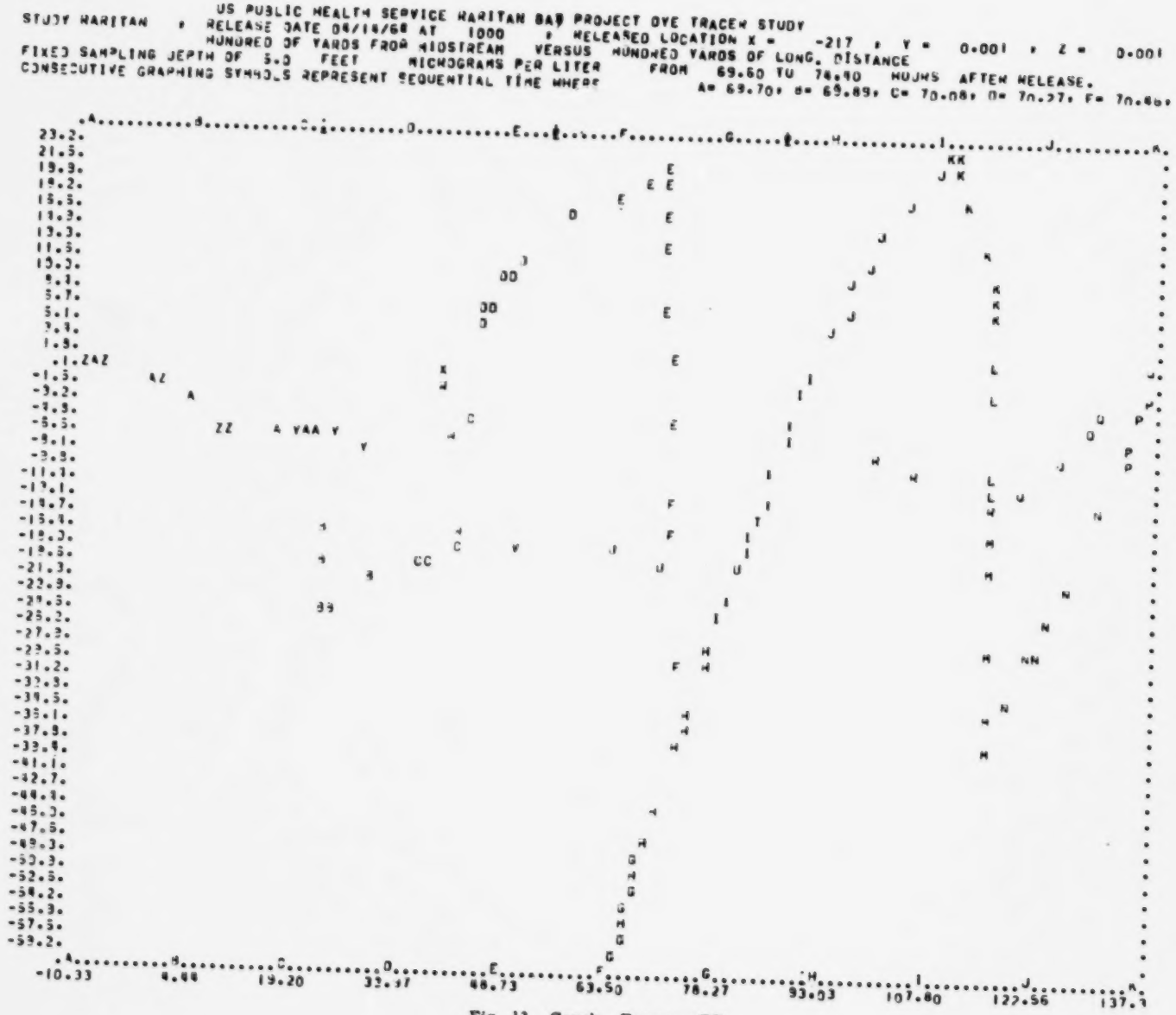

Fig. 13. Graph - Program TZ

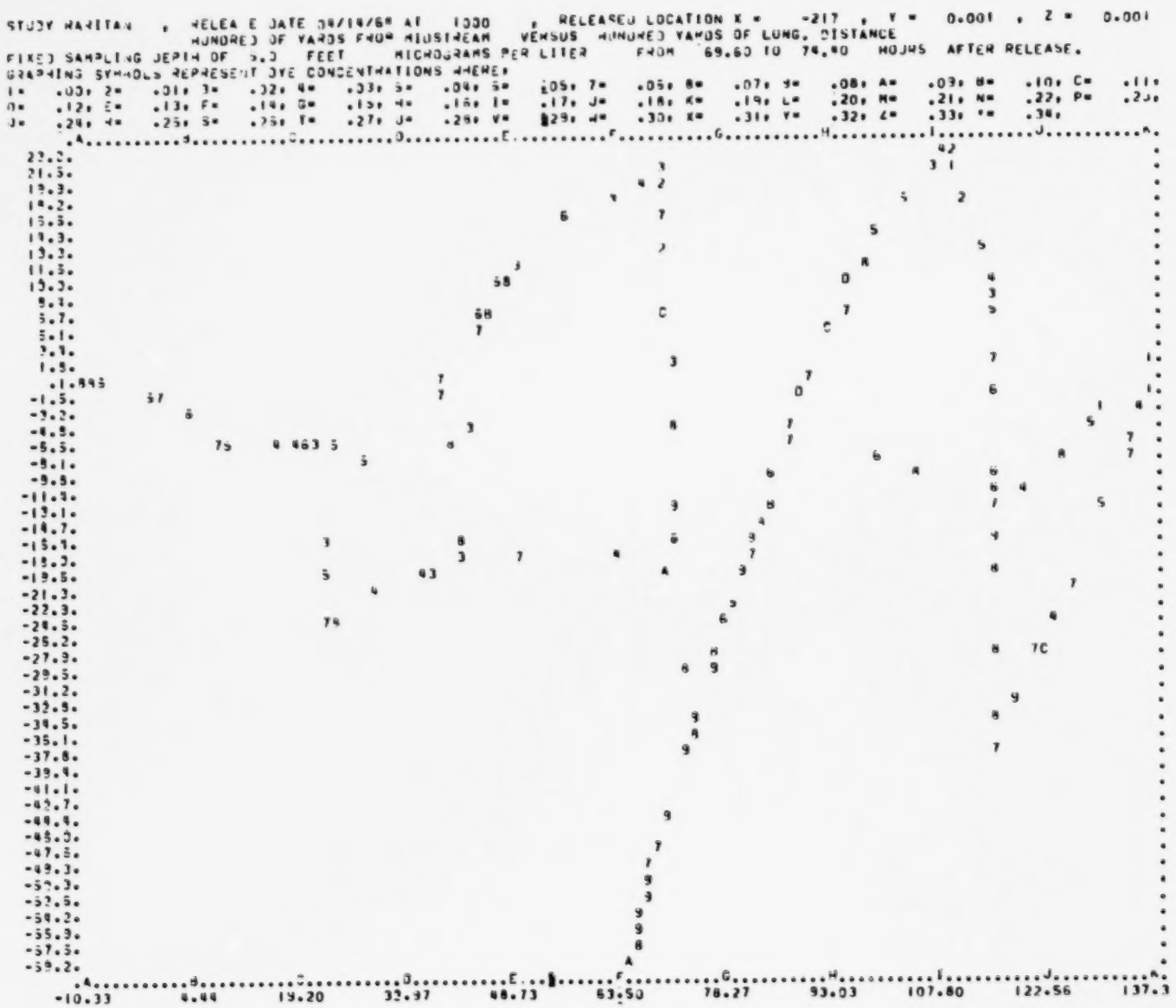
STUDY RARITAN , RELEA E DATE 08/19/68 AT 1030 , RELEASED LOCATION X = -217 , Y = 0.001 , Z = 0.001
HUNDRED OF YARDS FROM MIDSTREAM VERSUS HUNDRED YARDS OF LONG. DISTANCE
FIXED SAMPLING DEPTH OF 5.0 FEET MICROGRAMS PER LITER FROM 69.60 TO 74.40 HOURS AFTER RELEASE.
GRAPHING SYMBOLS REPRESENT DYE CONCENTRATIONS WHERE:
1= .03; 2= .01; 3= .02; 4= .03; 5= .04; 6= .05; 7= .05; 8= .07; 9= .08; A= .09; B= .10; C= .11;
D= .12; E= .13; F= .14; G= .15; H= .16; I= .17; J= .18; K= .19; L= .20; M= .21; N= .22; P= .23;
Q= .24; R= .25; S= .26; T= .27; U= .28; V= .29; W= .30; X= .31; Y= .32; Z= .33; *= .34;
-10.33
4.44
19.20
33.97
48.73
63.50
78.27
93.03
107.80
122.56
137.3

Fig. 14. Graph - Program TZ

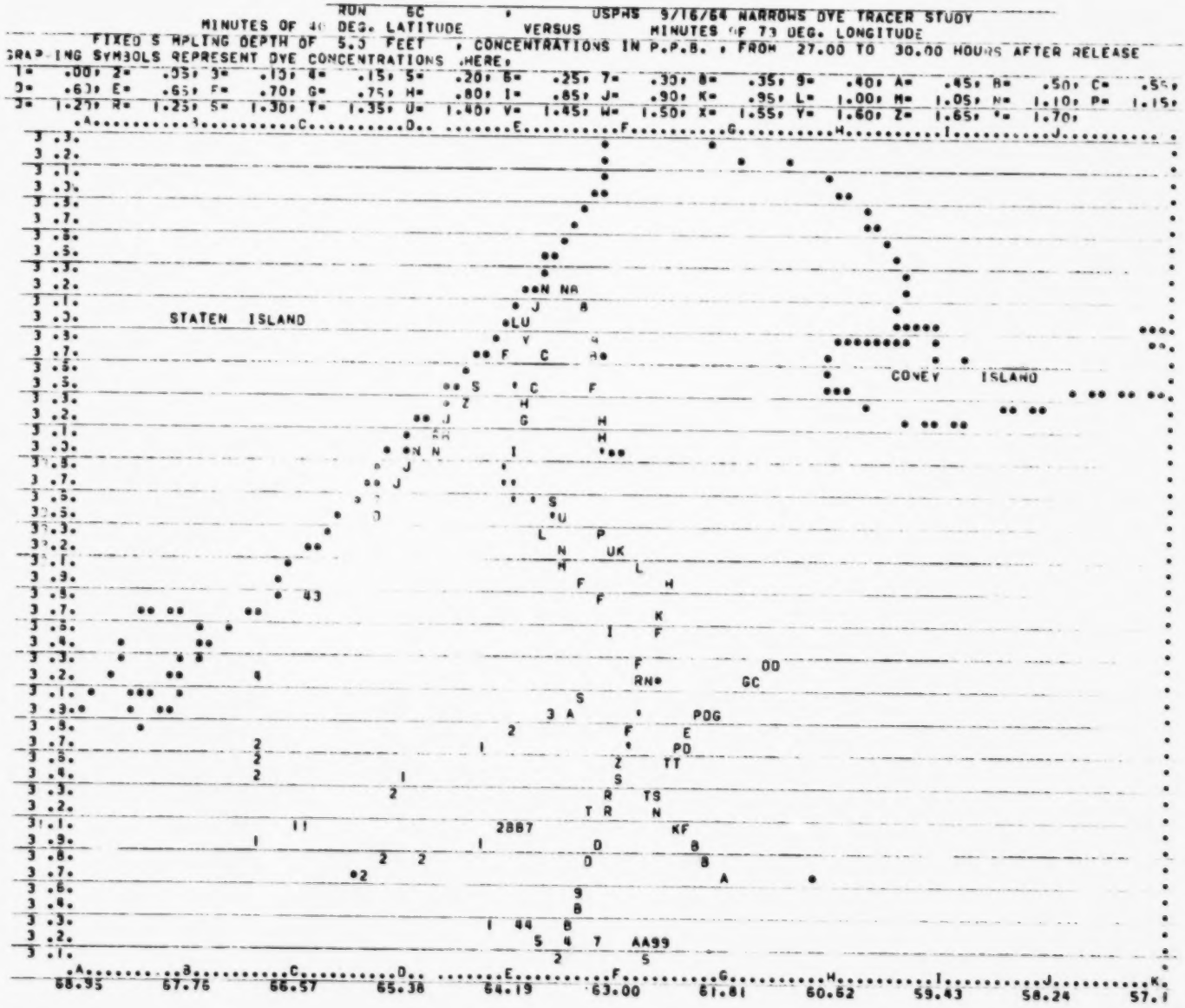
RUN 6C
USPHS 9/16/64 NARROWS DYE TRACER STUDY
MINUTES OF 40 DEG. LATITUDE VERSUS MINUTES OF 73 DEG. LONGITUDE
FIXED SAMPLING DEPTH OF 5.0 FEET , CONCENTRATIONS IN P.P.B. , FROM 27.00 TO 30.00 HOURS AFTER RELEASE
GRAPHING SYMBOLS REPRESENT DYE CONCENTRATIONS AS HERE,
1= .00, 2= .05, 3= .10, 4= .15, 5= .20, 6= .25, 7= .30, 8= .35, 9= .40, A= .45, B= .50, C= .55,
D= .60, E= .65, F= .70, G= .75, H= .80, I= .85, J= .90, K= .95, L= 1.00, M= 1.05, N= 1.10, P= 1.15,
Q= 1.20, R= 1.25, S= 1.30, T= 1.35, U= 1.40, V= 1.45, W= 1.50, X= 1.55, Y= 1.60, Z= 1.65, *= 1.70,
STATEN ISLAND
CONEY ISLAND
68.95
67.76
66.57
65.38
64.19
63.00
61.81
60.62
59.43
58.24
57.1

Figure 15. Graph - Program T2

Appendix II
Computer Programs

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      PROGRAM NDYE                                                      NDYE 001
C     REVISED AUG. 65 TO EMPLOY EXPONENTIAL SLOPE INTERPOLATION         NDYE 003
C     1/20=M043  GROUPS 1 TO 7= MADISON  0/21=M040                      NDYE 002
C     INPUT 20,OUTPUT21 & MOUNT NEW TAPES IF NEEDED AT PAUSE            NDYE 004
      COMMON/DYE/     ID,LABEL(4),LABZ,LABX(4),LABY(4),LABC(3),LABP(3), NDYE 005
     1LABHP(3),LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI,LERTE,NK,SUMCX,   NDYE 006
     2SUMCX                                                             NDYE 007
      DIMENSION IDC(500),CSLI(60),U(9),V(3),CINI(60),CIND(60)           NDYE 008
      DIMENSION TAPE(500),FR(500),LSCALE(500),KS(500),KE(500),TEMP(500) NDYE 009
      COMMON/DYE/KAX,NV(100),T(500),X(500),Y(500),Z(500),C(500)         NDYE 010
      IT=20$NM=21$KT=51$DU7777LLLL=1.1$PAUSE$ME=INDTT$ME=INDNM$KK=0     NDYE 011
   40 FORMAT(1H0,12,1H,,4A8,1H,,8A4)                                    NDYE 012
      READ(50,50) KAX,ID,LABEL,AN,LABZ,LABX,LABY                        NDYE 013
      WRITE(KT,50)KAX,ID,LABEL,AN,LABZ,LABX,LABY                        NDYE 014
      WRITE(NM,50)KAX,ID,LABEL,AN,LABZ,LABX,LABY                        NDYE 015
      READ(50,55)LABC,LABP,LABHP,LERDA,LERTI,LERX,LERY,LERZ             NDYE 016
      LABTE=8HDEG.CENT + LABTI = HH  HOURS                              NDYE 017
      WRITE(NM,55)LABC,LABP,LABHP,LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTINDYE 018
      WRITE(KT,55)LABC,LABP,LABHP,LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTINDYE 019
   55 FORMAT(1H0,9A8)                                                   NDYE 020
   57 KK = KK+1                                                         NDYE 021
      READ(IT,90)NTOT,METER$WRITE(KT,91)NTOT,METER$IF(NTOT) 89,89,85    NDYE 022
   90 FORMAT (1X,I2,10X,I3)                                             NDYE 023
   85 DO 88  N = 1, NTOT                                                NDYE 024
      READ(IT,80)K,TLOW,DELT,ME,CINI(K),CIND(K),CSLI(K)                 NDYE 025
      WRITE(KT,70)K,TLOW,DELT,ME,CINI(K),CIND(K),CSLI(K)                NDYE 026
      IF(ME-METER) 87,88,87                                             NDYE 027
   87 WRITE OUTPUT TAPE KT,60                                           NDYE 028
   60 FORMAT ( 23HUSE WRONG IN METER NUMBER, )                          NDYE 029
   80 FORMAT(1X I2,1X 2F4.0,I4,2F7.3,F8.3)                              NDYE 030
C  70 FORMAT (1HU, I5, 2F10.1,I10,4F10.3)                              NDYE 031
   70 FORMAT (1HU, I5, 2F15.6,I10,4F15.6)                               NDYE 032
   88 CONTINUE                                                          NDYE 033
   89 CONTINUE$DO55 M=1,500$READ(IT,100)U,IU,V,IDC(M)$IF(EOF,IT)54,51   NDYE 034
   51 DAY=U(1)$HOUR=U(2)$TMIN=U(3)$X(M)=U(4)$Y(M)=U(5)$Z(M)=U(6)        NDYE 035
      FEET=U(7)$MCN=U(8)$FR(M)=U(9)$LSCALE(M)=IU$TEMP(M)=V(1)$SM=V(2)   NDYE 036
      SM=V(3)$TAPE(M)=FEET+MCN*1/12.06T(M)=0.0$IF(HOUR)112,112,111      NDYE 037
C     WRITE OUTPUT TAPE KT,900,M,DAY,HOUR,TMIN,X(M),Y(M),Z(M),          NDYE 038
C    XFEET,MCN,FR(M),LSCALE(M),TEMP(M),SM,SM,TAPE(M)                    NDYE 039
  900 FORMAT (1H ,I4,9F7.1,I5,4F7.1)                                    NDYE 040
  100 FORMAT(1X,F2.0,1X,2F2.0,2(1X,F5.0),1X,F3.0,1X,F2.0,F3.1,1X,F3.0,  NDYE 041
     1 1X,I2,F3.0,1X,2F2.0,4A,4A8)                                      NDYE 042
  111 T(M)= (DAY-1.0) * 24.0 + HOUR +SM +(TMIN-SM)/60.0                 NDYE 043
  112 CONTINUE                                                          NDYE 044
   55 CONTINUE $ WRITE(KT,400)KK  $  GO TO 99                           NDYE 045
   91 FORMAT (1H1,I2,10X,I3)                                            NDYE 046
  400 FORMAT (1H1,14,19HTH RECORD TOO LONG     )                       NDYE 047
   54 MAX = M-1                                                         NDYE 048
      CALL HILO(MAX,T,KS,KE) $ CALL SPINT (MAX,TAPE,KS,KE,T)           NDYE 049
      CALL HILO(MAX,X,KS,KE) $ CALL SPINT (MAX,T,KS,KE,X)              NDYE 050
      CALL HILO(MAX,Y,KS,KE) $ CALL SPINT (MAX,T,KS,KE,Y)              NDYE 051
      CALL HILO(MAX,Z,KS,KE) $ CALL SPINT (MAX,T,KS,KE,Z)              NDYE 052
      CALL HILO(MAX,TEMP,KS,KE) $ CALL SPINT(MAX,T,KS,KE,TEMP)         NDYE 053
      IF (LSCALE(1)) 10,10,5                                            NDYE 054
    5 KS(1)=1$DO12K=2,MAX$KS(K)=K$IF(LSCALE(K))11,11,12                 NDYE 055
   11 KS(K) = KS(K-1)                                                   NDYE 056
   12 CONTINUE $ DO 9 K=1,MAX $ KSK=KS(K)                               NDYE 057
  300 FORMAT(2HHU,I3 SCALE FOR READING NUMBER   ,I10)                   NDYE 058
    7 LSK=LSCALE(KSK)$ C(K)=0.0 $ IF(FR(K)) 9,9,8                       NDYE 059
    8 DIF= TEMP(K)-TLOW $CC=CINI(LSK)+CIND(LSK) * DIF/DELT              NDYE 060
      TT=.02/DELT $ C(K)=CSLI(LSK)*FR(K)*(1.0+TT*(1.0+(T/2.0)))+CC      NDYE 061
   20 FORMAT (3I5,1PE10.4)                                              NDYE 062
    9 CONTINUE$CALL HILO(MAX,C,KS,KE)$CALL SPINT(MAX,T,KS,KE,C)         NDYE 063
      WRITE TAPE 21,(X(L),Y(L),Z(L),T(L),C(L),L=1,MAX)                  NDYE 064
      DO 39 M=1,MAX $ MI=M-1 $ IF(XMODF(MI,50)) 36,40,37                NDYE 065
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      WRITE(KT,30)LABEL,IU,LENDA,LENTI,LENX,LENY,LABX,LABY,LABZ,LABTI,LANDYE 066
     1NC,LABTE ,KK,KAX,KAX                                                NDYE 067
C     30 FORMAT(1H1,27X,8HA=/1H0,14X,6HSTUDY A8,8X,13HRELEASE DATE A8,20HHELNDYE 068
      30 FORMAT(1H1,27X,8HA8/1H0,14X,6HSTUDY A8,5X,9HRELEASED A8,4H AT A8,21H HELNDYE 069
     1EASED LOCATIO  A8,A8,5H  ,Y=A8/3HUX=4A8,6H ,  T=A8,7H ,  Z= A8,4H NDYE 070
     2,  5HTIME=A8,14H AFTER RELEASE/1H0,8X,4HCONC,=3A8,1H,7X,5HTEMP=A8,1HNDYE 071
     3,15X,5HGROUP)3,6H OF I3,11H CONTAINING I4,13H OBSERVATIONS     ///4X NDYE 072
     4,1HN,4X,7HCARD ID3X,4HX(),LENGTH,6X,5HFL.R,6X,5HSCALE 4X,5HTEMP,6X,5HHOUNDYE 073
     5,5HCONC,10X,1HX,10X,1HY,10X,1HZ//)                                  NDYE 074
      37 WRITE(51,40)M,IDC(M),TAPE(M),FN(M),LSCALE(M),TEMP(M),T(M),C(M),  NDYE 075
     1X(M),Y(M),Z(M)                                                      NDYE 076
C     37 CONTINUE                                                          NDYE 077
      40 FORMAT(I5,3X,A8,F11.2,F11.0,I11,F11.1,5F11.2)                     NDYE 078
      39 CONTINUE  5  IF(KAA-KK) 58,58,57                                  NDYE 079
      58 REWIND NN                                                         NDYE 080
    7777 CONTINUE  6  GO TO 99                                             NDYE 081
      10 WRITE OUTPUT TAPE KT,300,LSCALE(1)                                NDYE 082
         LSCALE(1)=300GO TO 5                                              NDYE 083
      99 CONTINUE                                                          NDYE 084
         END                                                               NDYE 085

         SUBROUTINE HILO (KAX,Z,IZ,NZ)                                     HILO  01
         DIMENSION Z(1),IZ(1),NZ(1)                                        HILO  02
         KT=51                                                             HILO  03
         IF (Z(1)) 1,11,1                                                  HILO   4
       1 IZ(1)=1                                                           HILO  05
         DO 5  K=2,KAX                                                     HILO  06
         ZK=Z(K)                                                           HILO  07
         IF (ZK) 4,3,4                                                     HILO   8
       3 IZ(K) = IZ(K-1)                                                   HILO  10
         GO TO 5                                                           HILO  11
       4 IZ(K) = K                                                         HILO  12
       5 CONTINUE                                                          HILO  13
         IF (Z(KAX))  6,12,6                                               HILO  14
       6 NZ(KAX) = KAX                                                     HILO  15
         KAXM1 = KAX-1                                                     HILO  16
         DO 10  KK=1,KAXM1                                                 HILO  17
         K=KAX-KK                                                          HILO  18
         ZK=Z(K)                                                           HILO  19
         IF (ZK) 9,8,9                                                     HILO  20
       8 NZ(K) = NZ(K+1)                                                   HILO  21
         GO TO 10                                                          HILO  22
       9 NZ(K) = K                                                         HILO  23
      10 CONTINUE                                                          HILO  24
         RETURN                                                            HILO  25
      11 WRITE OUTPUT TAPE KT,100,Z(1), KAX,Z(KAX)                         HILO  26
     100 FORMAT (12H0I  , F25.2, I10, F25.2)                               HILO  27
         GO TO 6                                                           HILO  28
      12 WRITE OUTPUT TAPE KT,100,Z(1), KAX,Z(KAX)                         HILO 28A
         GO TO 6                                                           HILO 28B
         END                                                               HILO  29

         SUBROUTINE SPINT (KAX,DEP,IZ,NZ,Z)                               SPINT 01
         DIMENSION DEP(1), IZ(1), NZ(1), Z(1)                              SPINT 02
         KT = 51                                                           SPINT 03
         DO 2  K=1,KAX                                                     SPINT 04
         IZK = IZ(K)                                                       SPINT 05
         NZK = NZ(K)                                                       SPINT 06
         IF (IZK - NZK)  1,2,3                                             SPINT 07
       1 Z(K)=Z(IZK)+(Z(NZK)-Z(IZK))*(DEP(K)-DEP(IZK))/(DEP(NZK)-DEP(IZK)) SPINT 08
       2 CONTINUE                                                          SPINT 09
         RETURN                                                            SPINT 10
       3 WRITE OUTPUT TAPE KT,10,K,IZK,NZK,Z(K),Z(IZK),Z(NZK)              SPINT 11
      10 FORMAT (12H0SPINT ERROR 3I15, 3F20.3)                             SPINT 12
         RETURN                                                            SPINT 13
         END                                                               SPINT 14
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      PROGRAM TYZ                                                          TYZ  001
C     USES  INPUT 21   H107                                                TYZ  002
C THIS IS A TRIVIAL PROGRAM CALLING SUBROUTINE TYZFIX,NO COMMON OR         TYZ  003
C DIMENSION NEEDED. PACKAGE NEEDS 4 ROUTINES WITH COMMON DYE AND LINE.     TYZ  004
C GLINE,TYZFIX,VIAT,AND WEIGHT. GLINE DYE COMMON IS SPECIAL. 5 ROUTINES    TYZ  005
C WITHOUT COMMON,RSCALE,DYGL,DYSP,HSCALE, AND INSIDEF.                     TYZ  006
      COMMON/SET/NP(20),XW(50),XMIN,XMAX                                   TYZ  007
      DATA(XW=-219.,.055,.028,-179.,.099,.028,-126.,.23,.042,-102.,.26,.TYZ  008
     105.-78.,.30.,.084,-52.,.56,.14,3.,1.57)                              TYZ  009
C     DATA(XW=-160.0,.099,.028,-126.,.23,.042,-116.,1.57)                  TYZ  010
      CALL EASY (  6.07 ,  6.41 ,FT,TOL)                                   TYZ  011
      NP(1)=15NP(2)=-1     $  XMIN=-160.  $  XMAX=-116.                    TYZ  012
      CALL TYZFIX(FT,TOL,0.,5., 111,6,.05,8H 7/ 6/64)                      TYZ  013
      CALL TYZFIX(FT,TOL,0.,5.,-111,6,.05,8H 7/29/64)                      TYZ  014
      CALL TYZFIX(FT,TOL,0.,5., 100,6,.05,8H 7/29/64)                      TYZ  015
      CALL EASY(23.0,25.3,FT,TOL) $ NP(1)=0 $ NP(2)=1 $ NP(3)=-1           TYZ  016
      XMAX=-.1 $ XMIN=-126.                                                TYZ  017
C     CALL TYZFIX(FT,TOL,0.,5., 111,5,.05,8H 7/ 6/64)                      TYZ  018
      CALL TYZFIX(FT,TOL,0.,5., 111,6,.05,8H 7/ 6/64)                      TYZ  019
      END                                                                  TYZ  020

      SUBROUTINE EASY(TMIN,TMAX,FT,TOL)                                    EASY 001
      FT = (TMIN+TMAX)*.5  $  TOL=(TMAX-TMIN)*.5 $ RETURN                  EASY 002
      END                                                                  EASY 003

      SUBROUTINE TYZFIX(FT,TOL,FY,FZ,NGR,NW,DELC,LABRUN)                   TYZF 001
C     SUBROUTINE TYZFIX FOR TYZ                                            TYZF 002
      COMMON/IDYE/     ID,LABEL(8),LABZ,LABX(4),LABY(4),LABC(3),LABP(3),   TYZF 003
     1LABWP(3),LERDA,LENTI,LERX,LERY,LERZ,LABTE,LABTI,LENTE,NK,SUMCX,      TYZF 004
     2SUMCWX                                                               TYZF 005
      COMMON/SET/NP(20),XW(50),XMIN,XMAX                                   TYZF 006
      COMMON/LINE/COUNT(111),PCC(111),PWW(111),SCC(111),SWW(111),VV(111)   TYZF 007
     1,CC(51),VW(50),NGROU(20),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,     TYZF 008
     2NDIR,IT, KT,IN                                                       TYZF 009
      COMMON/DYE/    MAX,KAX,MAT(5),111)                                   TYZF 010
      IT=50 $ KT=51 $ IN=21                                                TYZF 011
            DO 1 L=1,50                                                    TYZF 012
    1 VW(L)=XW(L) $ DO 2 L=1,20                                            TYZF 013
    2 NGROU(L)=NP(L)$ JD=LABRUN$VMIN=XMIN$VMAX=XMAX                        TYZF 014
      RMIN(1)=FT-TOL $ RMAX(1)=FT+TOL $ RMIN(2)=FY-.0002$ TCUR=FT          TYZF 015
      RMIN(3)=FZ-.0002 $ RMAX(2)=FY+.0001 $ RMAX(3)=FZ+.0001               TYZF 016
      CALL GLINE      (NGR,NW,DELC)   $  RETURN                            TYZF 017
      END                                                                  TYZF 018

      FUNCTION INSIDEF (A,B,C)                                             INSI 001
      IF (B-A) 3,2,1                                                       INSI 002
    1 IF (C-B) 3,2,2                                                       INSI 003
    2 INSIDEF = 1    $ RETURN                                              INSI 004
    3 INSIDEF = 2    $ RETURN                                              INSI 005
      END                                                                  INSI 006

      SUBROUTINE SUB(X, JAX, S)                                            SUB  002
      DIMENSION X(1), S(1)                                                 SUB  003
      DO 1  J = 1, JAX                                                     SUB  004
    1 S(J)=0.0 $ DO 2 J=1,JAX $ DO 2 K=J,JAX                               SUB  005
    2 S(K) = S(K) + X(J)     $ RETURN                                      SUB  006
      END                                                                  SUB  007
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      SUBROUTINE VINT(N,*,INIT,VQ,CQ)                                   VINT 001
C     SUBROUTINE VINT FOR TYZ                                           VINT 002
      COMMON/IDYE/     ID,LABEL(8),LABZ,LABX(4),LABY(4),LABC(3),LABP(3), VINT 003
     1LABWP(3),LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI,LENTE,NK,SUMCX,    VINT 004
     2SUMCWX                                                            VINT 005
      DIMENSION    CCC(111), WWW(111)                                    VINT 006
      COMMON/LINE/COUNT(111),PCC(111),PWW(111),SCC(111),SWW(111),VV(111)VINT 007
     1,CC(51),VW(50),NGROU(20),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,  VINT 008
     2NDIR,IT, KT,IN                                                    VINT 009
      TNIF(R,S,G,H,RS) = G+(H-G)*(RS-R)/(S-R)                           VINT 010
      RQ=0.0 $ IF(VQ-VMIN) 1,4,2                                        VINT 011
    1 RQ=-1.0 $ GO TO 4                                                 VINT 012
    2 IF(VQ-VMAX) 4,4,3                                                 VINT 013
    3 RQ = 1.0                                                          VINT 014
    4 IF(INIT) 5,11,5                                                   VINT 015
    5 IF(RQ*RP) 6,6,9                                                   VINT 016
    6 VS=MIN1F(VP,VQ)$VS=MAX1F(VS,VMIN)$VE=MAX1F(VP,VQ)$VE=MIN1F(VE,VMAXVINT 017
     1) $ JS=(VS-VMIN)/DV+1.0       $  JE=(VE-VMIN)/DV + 1.0            VINT 018
      X1=VS $ X2=VE $ DELX=X2-X1                                        VINT 019
      CCC(JS)=          TNIF(VQ,VP,CQ,CP,VS)                            VINT 020
      CCC(JE)=            TNIF(VQ,VP,CQ,CP,VE )                         VINT 021
      DELX=ABSF(DELX) $ C=.5*(CCC(JS)+CCC(JE)) $ CDELX=C*DELX           VINT 022
      CCC(JS)=CCC(JS)*DV $ CCC(JE)=CCC(JE)*DV                           VINT 023
      DO 7  J=JS,JE                                                     VINT 024
    7 COUNT(J) = COUNT(J)+1.0                                           VINT 025
      WQ=WEIGHTF(XW,VQ) $ WP=WEIGHTF(XW,VP)                             VINT 026
      WWW(JS)=TNIF(VQ,VP,WQ,WP,VS) $ WWW(JE)=TNIF(VQ,VP,WQ,WP,VE)       VINT 027
      WW=.5*(WWW(JS)+WWW(JE)) $ WWW(JS)=WWW(JS)*CCC(JS)                 VINT 028
      WWW(JE)=WWW(JE)*CCC(JE)     $ SCC(JS)=SCC(JS)+CCC(JS)             VINT 029
      SWW(JS)=SWW(JS)+WWW(JS) $ IF(JE-JS) 12,13,12                      VINT 030
   12 SCC(JE)=SCC(JE)+CCC(JE)                                           VINT 031
      SWW(JE) = SWW(JE) + WWW(JE)                                       VINT 032
   13 WDELX = W*DELX                                                    VINT 033
      SUMCX=SUMCX+CDELX $ SUMWX=SUMWX+WDELX                             VINT 034
      FJE=JE$FJS=JS$FES=FJE-FJS$AV=(VE-VS)/FES$BV=(FJE*VS-FJS*VE)/FES   VINT 035
      AC=(CCC(JE)-CCC(JS))/FES$BC=(FJE*CCC(JS)-FJS*CCC(JE))/FES         VINT 036
      AW=(WWW(JE)-WWW(JS))/FES$BW=(FJE*WWW(JS)-FJS*WWW(JE))/FES         VINT 037
      JSP=JS+1 $ JEM=JE-1 $ FJ=FJS$ DO 8 J=JSP,JEM $ FJ=FJ+1.0          VINT 038
      SCCJ=FJ*AC+BC $ SCC(J)=SCC(J)+SCCJ                                VINT 039
      SWWJ=FJ*AW+BW $ SWW(J)=SWW(J)+SWWJ                                VINT 040
    8 CONTINUE                                                          VINT 041
      NK=NK+1                                                           VINT 042
      WRITE(KT,90) NK,JS,JE,X1,X2,DELX,C,W,CDELX,WDELX,SUMCX,SUMWX      VINT 043
   90 FORMAT(1X,I3,2I4,9F12.4)                                          VINT 044
      GO TO 11                                                          VINT 045
   10 FORMAT (///    I5,6F17.5,F13.2 )                                 VINT 046
    9 JS = 0.0                                                          VINT 047
   11 RP = RQ $ VP = VQ $ CP = CQ  $INIT=INIT+1                         VINT 048
C     WRITE(51,10) JS,RP,RQ,CP,CQ,VP,VQ                                 VINT 049
      RETURN                                                            VINT 050
      END                                                               VINT 051

      SUBROUTINE HSCALE(VV,NGRV,NDIR,S)                                 HSCL 001
      DIMENSION VV(111),S(11)                                           HSCL 003
      IF(NGRV-111) 1,3,6                                                HSCL 004
    1 DELV=VV(2)-VV(1) $ DO 2 N=NGRV,111                                HSCL 005
    2 VV(N) = VV(N-1) + DELV                                            HSCL 006
    3 DO 5 I=1,11 $ II=I $ IF(NDIR) 4,4,5                               HSCL 007
    4 II = 12-I                                                         HSCL 008
    5 S( I) =VV(11*II-10) $ RETURN                                      HSCL 009
    6 WRITE (51,10) NGRV  $  RETURN                                     HSCL 010
   10 FORMAT(14H1ERROR IN NGRV ,I10/(10E12.3))                          HSCL 011
      END                                                               HSCL 012
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      SUBROUTINE DYG1(QQQ,DELC,NWAY,LABC       ,LOWMYS         )          DYG1 001
      DIMENSION QQQ(111),S(11),LABC(3)                                    DYG1 003
      COMMON/IDYE/     ID,LABEL(N),LAHZ,LARX(4),LAHY(4),LFIL(3),LABP(3),  DYG1 004
     1LABWP(3),LEWDA,LEWTI,LEWX,LEWY,LERZ,LABTE,LABTI,LEWTE,NK,SUMCX,     DYG1 005
     2SUMCWX                                                              DYG1 006
      COMMON/DYE/   MAX,KAX,MAT(51,111)                                   DYG1 007
      COMMON/LINE/COUNT(111),PCC(111),PWW(111),SCC(111),SWW(111),VV(111)DYG1 008
     1,CC(51),VW(50),NGROU(20),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,   DYG1 009
     2NDIR,IT, KT,IN                                                      DYG1 010
      DATA(KNALB=20202020202020HB)                                        DYG1 011
      KT = 51  $ CMAX = 0.0  $ DO 1 N = 1,111  $ DO 11 J = 1,51           DYG1 012
   11 MAT(J,N) = KNALB                                                    DYG1 013
    1 CMAX=MAX1F(QQQ(N),CMAX)  $ DAX=50.5*DELC $ IF(CMAX-DAX) 5,5,2       DYG1 014
    2 NNN=CMAX/DAX  $  FNNN=NNN  $  IF(CMAX- FNNN * DAX ) 4, 4, 3        DYG1 015
    3 FNNN= FNNN+ 1.0                                                     DYG1 016
    4 DAX = FNNN * DAX                                                    DYG1 017
    5 DEL=DAX/50.5 $CMIN=-.5*DEL$CALL HSCALE (CMIN,DAX,51,DC, CC)         DYG1 018
C     WRITE(51,20)CMIN,CMAX,DAX,FNNN,DEL,DC,CC                          DYG1 019
      CALL HSCALE (VV,NGRV,NWAY,$ )                                       DYG1 020
      WRITE(KT,10)LABEL,ID,LEWDA,LEWTI,LEWX,LEWY,LERZ,RMIN(2),LABY,       DYG1 021
     1RMIN(1),RMAX(1),LABTI,LABC,LARX,RMIN(3),LAHZ                        DYG1 022
   10 FORMAT(1H1,18X 8AH/7HOSTUDY AH,5H  ,  13HRELEASE DATE A8,4H AT A8,DYG1 023
     1 5H  ,  21HRELEASED LOCATION X =A8,5H  ,  3HY =A8,5H  ,  3HZ =A8/ DYG1 024
     2                                    11H FIXED Y = F7.1,            DYG1 025
     3 1X 4A8,13X10HFIXED T = 5HFROM F6.2,4H TO F6.2,1XA8,1X              DYG1 026
     4 13HAFTER RELEASE/                                                  DYG1 027
     5 20X3A8,5X3HVS.,5X4A8,6X9HFIXED Z =F6.1,2XA8/)                      DYG1 028
      WRITE (51,20) S  $ WRITE (51,30)                                    DYG1 029
   20 FORMAT(10F11.2,F10.1)                                               DYG1 030
   30 FORMAT (7X2H=,A10(1H,),1HB10(1H,),1HC10(1H,),1HD10(1H,),1HE10(1H,),DYG1 031
     1 1HF10(1H,),1HG10(1H,),1HH10(1H,),1HI10(1H,),1HJ10(1H,),2HK,  )     DYG1 032
      NGRV1=NGRV+1 $ DO 9 N = 1,NGRV $ NN = N  $ IF(NWAY) 6, 7, 7         DYG1 033
    6 NN = NGRV1 - NN                                                     DYG1 034
    7 M= (QQQ(N) - CMIN ) / DC+1.0  $ MB=52-M $DO 8  J= MB,51             DYG1 035
    8 MAT(J, NN) = LOWMYS                                                 DYG1 036
    9 CONTINUE$DO12M=1,51$MB=52-M$WRITE(51,40)CC(MB),(MAT(M,J),J=1,NGRV)DYG1 037
   12 CONTINUE                                                            DYG1 038
   40 FORMAT (1X, F6.2, 1H=, 111A1, 1H,)                                  DYG1 039
      WRITE (KT,30) $ WRITE (KT,20), S  $ RETURN                          DYG1 040
      END                                                                 DYG1 041

      FUNCTION WEIGHTF(NW,VGIVEN)                                         WGHT 001
      COMMON/LINE/COUNT(111),PCC(111),PWW(111),SCC(111),SWW(111),VV(111)WGHT 002
     1,CC(51),VW(50),NGROU(20),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,   WGHT 003
     2NDIR,IT, KT,IN                                                      WGHT 004
      DATA(OMEGA=.50589)                                                  WGHT 005
C     OMEGA=2.0*3.14159266/12.42 $ NW2=3*NW+1 $ IF(TCUR) 4,4,1            WGHT 006
      NW2=3*NW +1 $    IF(TCUR)4,4,1                                      WGHT 007
    1 DO 2 N=4,NW2,3 $ IF(VGIVEN-VW(N)) 3,3,2                             WGHT 008
    2 CONTINUE $ WRITE (51,10) VGIVEN  $  NW=NW                           WGHT 009
   10 FORMAT(1H0 F20.5,10X 16HIS NOT IN RANGE,  )                         WGHT 010
C     PAUSE                                                               WGHT 011
    3 A=VW(N-2)$B=VW(N-1) $ FEE=VW(NW2+1) $ TC=TCUR $ GO TO 5             WGHT 012
    4 A=VW(2) $ B=VW(3) $ FEE=VW(5) $ TC=VGIVEN                           WGHT 013
    5 ANG=OMEGA * TC + FEE $ P=A+B*SINF(ANG) $ WEIGHTF=P                  WGHT 014
   20 FORMAT( 8HU=EIGHT = 2I5,E12.3,I5/( 35X,3F28.5))                     WGHT 015
      END                                                                 WGHT 016

      SUBROUTINE HSCALE(UMIN,UMAX,NGR,DU,UU)                              HSCL 001
      DIMENSION UU(1)                                                     HSCL 003
      FNGR=NGR $ DU=(UMAX-UMIN)/FNGR+.00000001                            HSCL 004
      UU(1)=UMIN+.5*DU $ DO 1 J=2,NGR                                     HSCL 005
    1 UU(J)=UU(J-1)+DU $ RETURN                                           HSCL 006
      END                                                                 HSCL 007
```

```
      PROGRAM XYZ                                                          XYZ  001
C     USES 1/21 = M107                                                     XYZ  002
C THIS IS A TRIVIAL PROGRAM CALLING SUBROUTINE TYZFIX,NO COMMON OR         XYZ  003
C DIMENSION NEEDED. PACKAGE NEEDS 4 ROUTINES WITH COMMON DYE AND LINE.     XYZ  004
C GLINE,TYZFIX,VINT,AND WEIGHT. GLINE DYE COMMON IS SPECIAL. 5 ROUTINES    XYZ  005
C WITHOUT COMMON,RSCALE,DYG1,DYSP,HSCALE, AND INSIDEF.                     XYZ  006
      COMMON/SET/NP(20),X(50),TMIN,TMAX                                    XYZ  007
      NP(1)=1$NP(2)=-1     $  TMIN=0.      $  TMAX=19.                     XYZ  008
      CALLXYZFIX(-74.,.00,5.,111,.01,8H08/11/65)                           XYZ  009
      DO 1 N=1,5                                                           XYZ  010
    1 NP(N)=0 $ NP(6)=1 $ NP(7)=1 $ NP(8)=-1 $ TMIN =30. $ TMAX=40.        XYZ  011
      CALLXYZFIX(-74.,.0,10.,111,.01,8H08/11/65)                           XYZ  012
      END                                                                  XYZ  013

      SUBROUTINE GLINE(    NGR,NW,DELC)                                    GLIN 001
C     SUBROUTINE GLINE FOR XYZ                                             GLIN 002
C     USE FOR TYZFIX. CHECK COMMON AND READ BINARY LIST                    GLIN 003
      COMMON/IDYE/     ID,LABEL(8),LABZ,LABX(4),LABY(4),LABC(3),LABP(3),   GLIN 004
     1LABWP(3),LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI,LERTE,NK,SUMCX,      GLIN 005
     2SUMCWX                                                               GLIN 006
      COMMON/DYE/    MAX,KAX,V(500),R2(500),R3(500),R1(500),C(500),       GLIN 007
     1FIL(3161)                                                            GLIN 008
      COMMON/LINE/COUNT(111),PCC(111),PWW(111),SCC(111),SWW(111),VV(111)GLIN 009
     1,CC(51),VM(50),NGROU(20),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,    GLIN 010
     2NDIR,IT, KT,IN                                                       GLIN 011
      NGRV=NGR $ NDIR=1          $        IF(NGR) 1,1,2                    GLIN 012
    1 NDIR = -1  $  NGRV = -NGR                                            GLIN 013
    2 CONTINUE          $ CALL HSCALE(VMIN,VMAX,NGRV,DV,VV)                GLIN 014
   50 FORMAT(1H0,I2,1H,8A8,1H,8A8)                                         GLIN 015
      NK=0$SUMCX=0.0$SUMWX=0.0$DO18N=1,NGRV$SCC(N)=0.0$SWW(N)=0.0          GLIN 016
   18 COUNT(N)=0.0                                                         GLIN 017
      READ(IN,50) KAX,ID,LABEL,NN,LABZ,LABX,LABY                           GLIN 018
      WRITE(KT,50)KAX,ID,LABEL,NN,LABZ,LABX,LABY                           GLIN 019
      READ(IN,55)LABC,LABP,LABWP,LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI    GLIN 020
      WRITE(KT,55)LABC,LABP,LABWP,LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTIGLIN 021
   55 FORMAT(1H0,9A8)                                                      GLIN 022
      WRITE(KT,60)LABEL,ID,LERDA,LERTI,LERX,LERY,LERZ,RMIN(1),LABX,RMIN(GLIN 023
     13),LABZ,RMIN(2),LABY,VMIN,VMAX,LABTI                                 GLIN 024
   60 FORMAT(1H1,18X 8A8/7H0STUDY A8, 4H  , 13HRELEASE DATE A8,4H AT A8,GLIN 025
     1 5H  ,  21HRELEASED LOCATION X =A8,5H  ,  3HY =A8,5H  ,  3HZ =A8/ GLIN 026
     29H0FIXED X=F6.1,1X,A8,1H,8HFIXED Z=F6.1,1X,A8,1H,8HFIXED Y=F6.1,1X GLIN 027
     34A8//30X10HTIME FROM F7.1,4H TO F7.1,1XA8,2X13HAFTER RELEASE)       GLIN 028
      WRITE(KT,70)                                                         GLIN 029
   70 FORMAT(1H02X1HN,16X6HFROM,10X2HTO,8X6HDELT,6X6HAVER C                GLIN 030
     17X,5HCDELX,7X,5HSUM C//)                                            GLIN 031
      DO 11 K=1,KAX $ NGP = NGROU(K)                                       GLIN 032
              READ(IN) ID,MAX,(R1(M),R2(M),R3(M),V(M),C(M),M=1,MAX)        GLIN 033
C     WRITE (KT,300) (M,R1(M),R2(M),R3(M),V(M),C(M),M=1,MAX)               GLIN 034
      WRITE (KT,200) ID,K,MAX,(RMIN(I),RMAX(I),I=1,3),VMIN,VMAX           GLIN 035
  200 FORMAT(1H0,A8,2I5/(20X,2F30.5))                                      GLIN 036
  300 FORMAT(1H1/(I5,5F22.4))                                              GLIN 037
      IF (NGP)19,11,4                                                      GLIN 038
    4 INIP=-1$DO9 M=1,MAX                                                  GLIN 039
      NGOR1=INSIDEF(RMIN(1),R1(M),RMAX(1))$GO TO (6,9),NGOR1               GLIN 040
    6 NGOR2=INSIDEF(RMIN(2),R2(M),RMAX(2))$GO TO(7,9),NGOR2                GLIN 041
    7 NGOR3=INSIDEF(RMIN(3),R3(M),RMAX(3)) $GO TO (8,9),NGOR3              GLIN 042
    8 VQ=V(M) $ CQ=C(M) $ IF(M-INIP-1)3,5,3                                GLIN 043
    3 INIP=M $ INIT=0                                                      GLIN 044
    5 CALL VINT(N,INIT,VQ,CQ) $ INIP=M                                     
   13 SCC(N)=SCC(N)/COUNT(N)                                               GLIN 050
   14 CONTINUE $  TCC=0.0  $  TWW=0.0                                      GLIN 051
      CALL DYG1(SCC,DELC,NDIR,LABC,       8H*********)                   GLIN 052
   30 FORMAT(3I10,4F20.5)                                                  GLIN 053
      A = VV(1)-.5*DV                                                      GLIN 054
      DO 15 N=1,NGRV  $ TCC=TCC+SCC(N)                                     GLIN 055
   15 CONTINUE   $   CALL SUB(SCC,NGRV,PCC)                                GLIN 056

      DO 17 N=1,NGRV                                                       GLIN 057
      PCC(N)=PCC(N)/TCC                          $ B=A+DV                  GLIN 058
      WRITE(KT,40)A,N,A,VV(N),B,SCC(N),       PCC(N),       COUNT(N),      GLIN 059
     1TCC      $  A=B                                                      GLIN 060
   17 CONTINUE                                                             GLIN 061
   40 FORMAT(2I4,3F8.2,4F10.3, F8.0,2F20.3)                                GLIN 062
      DC = .0200000001 $ CALL DYG1(PCC,DC,NDIR,LABP      ,8HCCCCCCCCC  )  GLIN 063
   21 RE=IND IN $ RETURN                                                   GLIN 064
      END                                                                  GLIN 065
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      SUBROUTINE XYZFIX(FX,FY,FZ,NGR,DELC,LABRUN)                                XYZF 001
C     SUBROUTINE XYZFIX FOR XYZ                                                  XYZF 002
      COMMON/IDYE/     ID,LABEL(8),LABZ,LABX(4),LABY(4),LABC(3),LABP(3),         XYZF 003
     1LAB#P(3),LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI,LERTE,NK,SUMCX,            XYZF 004
     2SUMC#X                                                                     XYZF 005
      COMMON/SET/NP(20),XW(50),TMIN,TMAX                                         XYZF 006
      COMMON/LINE/COUNT(111),PCC(111),PW#(111),SCC(111),SW#(111),VV(111)         XYZF 007
     1,CC(51),V#(50),NGROU(20),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,           XYZF 008
     2NDIR,IT, KT,IN                                                             XYZF 009
      COMMON/DYE/    MAX,KAX,MAT(51,111)                                         XYZF 010
      IT=50 $ KT=51 $ IN=21                                                      XYZF 011
            DO 1 L=1,50                                                          XYZF 012
    1 V#(L)=XW(L) $ DO 2 L=1,20                                                  XYZF 013
    2   NGROU(L)=NP(L)$ JD=LABRUN$VMIN=TMIN$VMAX=TMAX                            XYZF 014
      RMIN(1)=FX-.0002 $ RMIN(2)=FY-.0002 $ RMIN(3)=FZ-.0002                     XYZF 015
      RMAX(1)=FX+.0002 $ RMAX(2)=FY+.0002 $ RMAX(3)=FZ+.0002                     XYZF 016
      CALL GLINE      (NGR,N#,DELC)  $  RETURN                                   XYZF 017
      END                                                                        XYZF 018

      SUBROUTINE VINT(N#,INIT,VQ,CQ)                                             VINT 001
C     SUBROUTINE VINT FOR XYZ                                                    VINT 002
      COMMON/IDYE/     ID,LABEL(8),LABZ,LABX(4),LABY(4),LABC(3),LABP(3),         VINT 003
     1LAB#P(3),LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI,LERTE,NK,SUMCX,            VINT 004
     2SUMC#X                                                                     VINT 005
      DIMENSION    CCC(111), #W#(111)                                            VINT 006
      COMMON/LINE/COUNT(111),PCC(111),PW#(111),SCC(111),SW#(111),VV(111)         VINT 007
     1,CC(51),V#(50),NGROU(20),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,           VINT 008
     2NDIR,IT, KT,IN                                                             VINT 009
      TNIF(R,S,G,M,RS) = G+(M-G)*(RS-R)/(S-R)                                    VINT 010
      RQ=0.0 $ IF(VQ-VMIN) 1,4,2                                                 VINT 011
    1 RQ=-1.0 $ GO TO 4                                                          VINT 012
    2 IF(VQ-VMAX) 4,4,3                                                          VINT 013
    3 RQ = 1.0                                                                   VINT 014
    4 IF(INIT) 5,11,5                                                            VINT 015
    5 IF(RQ*RP) 6,6,9                                                            VINT 016
    6 VS=MIN1F(VP,VQ)$VS=MAX1F(VS,VMIN)$VE=MAX1F(VP,VQ)$VE=MIN1F(VE,VMAX)VINT 017
     1) $ JS=(VS-VMIN)/DV+1.0       $  JE=(VE-VMIN)/DV + 1.0                     VINT 018
      X1=VS $ X2=VE $ DELX=X2-X1                                                 VINT 019
      CCC(JS)=          TNIF(VQ,VP,CQ,CP,VS)                                     VINT 020
      CCC(JE)=            TNIF(VQ,VP,CQ,CP,VE )                                  VINT 021
      DELX=ABSF(DELX) $ C=.5*(CCC(JS)+CCC(JE)) $ CDELX=C*DELX                    VINT 022
      CCC(JS)=CCC(JS)*DV $ CCC(JE)=CCC(JE)*DV                                    VINT 023
      DO 7  J=JS,JE                                                              VINT 024
    7 COUNT(J) = COUNT(J)+1.0                                                    VINT 025
      SCC(JS) = SCC(JS) + CCC(JS)                                                VINT 026
                                    IF(JE-JS)12,13,12                            VINT 027
   12 SCC(JE) = SCC(JE) + CCC(JE)                                                VINT 028
   13 SUMCX=SUMCX+CDELX                                                          VINT 029
      FJE=JE$FJS=JS$FES=FJE-FJS$AV=(VE-VS)/FES$BV=(FJE*VS-FJS*VE)/FES            VINT 030
      AC=(CCC(JE)-CCC(JS))/FES$BC=(FJE*CCC(JS)-FJS*CCC(JE))/FES                  VINT 031
      JSP=JS+1 $ JEM=JE-1 $ FJ=FJS$ DO 8 J=JSP,JEM $ FJ=FJ+1.0                   VINT 032
      SCCJ=FJ*AC+BC $ SCC(J)=SCC(J)+SCCJ                                         VINT 033
    8 CONTINUE                                                                   VINT 034
      NK=NK+1                                                                    VINT 035
      #RITE(KT,90) NK,JS,JE,X1,X2,DELX,C,  CDELX,       SUMCX                    VINT 036
   90 FORMAT(1X,I3,2I4,9F12.2)                                                   VINT 037
      GO TO 11                                                                   VINT 038
   10 FORMAT (///    I5,6F17.5,F13.2 )                                         VINT 039
    9 JS = 0.0                                                                   VINT 040
   11 RP = RQ $ VP = VQ $ CP = CQ  $INIT=INIT+1                                  VINT 041
C     #RITE(51,10) JS,RP,RQ,CP,CQ,VP,VQ                                          VINT 042
      RETURN                                                                     VINT 043
      END                                                                        VINT 044
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```
      PROGRAM TZFHX                                                          TZ   001
C     USES 1/21 = M122                                                       TZ   002
      COMMON/SET2/NP(20),IT,KT,IN                                            TZ   003
      IT=50 $ KT=51 $ IN=21                                                  TZ   004
      NP(1)=0$NP(2)=0$NP(3)=0$NP(4)=1$NP(5)= 1 $  NP(6)=1                    TZ   005
      CALL TZFIX(72.0,2.4,5.0,0.,-11.,138.,111.,-60.,24.,.01,8HTEST RUN)     TZ   006
      END                                                                    TZ   007

      SUBROUTINE HAREA(XMIN,XMAX,YMIN,YMAX,NGR,NDIR,NLINE,DX,DY)             HAREA001
      COMMON/XY/LTXY(51,14),LCXY(51,14),XX(111),YY(51),CC(35),               HAREA002
     1J0,TT(25),LABEL(8),LABZ,LABX(4),LABY(6),LABC(3),LAMP(3),LABWP(3),      HAREA003
     2LERDA,LERTI,LERX,LERY,LERZ,LAHTE,LAHTI,LERTE                           HAREA004
      DIMENSION XV(6), LMV(6), YV(6)                                         HAREA005
      DATA(KNALB=20202020202020202OH)                                        HAREA006
      IT = 19       $  RE=IND 19                                             HAREA007
            DO 1 N=1,714 $ LCXY(N)=KNALB $ NGR1=NGR+1                        HAREA008
    1 LTXY(N)=KNALB $ DO 5 N=1,NLINE $ READ(IT,10)(XV(J),LMV(J),YV(J),       HAREA009
     1 J=1,6)                                                                HAREA010
C     WRITE(51,30)(XV(J),LMV(J),YV(J),J=1,6)                                 HAREA011
   30 FORMAT (6(1X,F8.2,1X,A1,1X,F8.2))                                      HAREA012
   10 FORMAT (6(1X,F5.3,A1,F5.3))                                            HAREA013
      DO 4 J=1,6 $ NGOX=INSIDEF(XMIN,XV(J),XMAX)$GO TO (2,4),NGOX            HAREA014
    2 NGOY=INSIDEF(YMIN,YV(J),YMAX)$ GO TO (3,4),NGOY                        HAREA015
    3 NY=(YV(J)-YMIN)/DY+1.0                $ NX=(XV(J)-XMIN)/DX+1.0         HAREA016
      LA=LMV(J) $ LIF=LA $ DO 41 K=2,8 $ LA=LA*64                            HAREA017
   41 LIF = LIF.OR.LA                                                        HAREA018
      CALL POSTS(NGR1,NDIR,NX,NY,LIF,LCXY)                                   HAREA019
      CALL POSTS(NGR1,NDIR,NX,NY,LIF,LTXY)                                   HAREA020
    4 CONTINUE                                                               HAREA021
    5 CONTINUE                                                               HAREA022
   20 FORMAT(1H1/(6X,1H,,13A8,A7,1H,))                                       HAREA023
                     RE=IND 19                                               HAREA024
C     WRITE(51,20)((LCXY(L,M),M=1,14),L=1,51)                                HAREA025
      RETURN                                                                 HAREA026
      END                                                                    HAREA027

      SUBROUTINE DYG2(XX,YY,MAT,NGRX,NDIR)                                   DYG2 001
      DIMENSION XX(111),YY(51),MAT(51,14),S(11)                              DYG2 002
      KT=51$CALL HSCALE(XX,NGRX,NDIR,S) $ WRITE(51,30)                       DYG2 003
   20 FORMAT (10F11.2,2F10.1)                                                DYG2 004
   30 FORMAT (7X 2H,A10(1H,),1HB10(1H,),1HC(10(1H,),1HD10(1H,),1HE10(1H,DYG2 005
     1), 1HF10(1H,),1HG10(1H,),1HH10(1H,),1HI10(1H,),1HJ10(1H,),2HK,)     DYG2 006
      DO 1 MB=1,51 $ MB = 52-M                                               DYG2 007
    1 WRITE OUTPUT TAPE KT,40,YY(MB),(MAT(MB,J), J=1,14)                     DYG2 008
   40 FORMAT (   F7.1,1H,,13A8,A7,1H, )                                      DYG2 009
      WRITE (51,30) $ WRITE (51,20) $    $ RETURN                            DYG2 010
      END                                                                    DYG2 011

      SUBROUTINE POSTS(NGR1, DIR,JV,NC,LOHMYS,MAT)                           POSTS001
      DIMENSION MAT (51,14), LD(8), LE(8)                                    POSTS002
      DIMENSION NGROUP(20),LIHV(25),LCHV(35)                                 POSTS003
      DATA(LD=77000000000000008,  770000000000008,    7700000000008,       POSTS004
     1 770000000H, 77000000B, 7700008, 77008, 77H)                           POSTS005
      DATA(LE=  777777777777778,77007777777777778,777700777777777B,         POSTS006
     1-77000000008,-7700000B,-770008,-77008,-77H)                            POSTS007
      NV = JV  $  IF(NDIR) 1,1,2                                             POSTS008
    1 NV = NGR1-JV                                                           POSTS009
    2 NW = (NV -1) / 8 $NP=NV-8 * NW $ NW = NW + 1                           POSTS010
C     WRITE(51,10) NV,NC,NW,NP,LD(NP),LE(NP),LOHMYS,MAT(NC,NW)               POSTS011
   10 FORMAT(1H0,4I5,2(2H ,016,2H ),2(2H ,,A8,2H, ))                         POSTS012
      MAT(NC,NW)=MAT(NC,NW).AND.LE(NP).OR.LOHMYS.AND.LD(NP)                  POSTS013
C     WRITE (51,20)  MAT(NC,NW)                                              POSTS014
   20 FORMAT (61X, 2H , A8, 1H,)                                             POSTS015
      RETURN                                                                 POSTS016
      END                                                                    POSTS017

      SUBROUTINE HSCALE(VV,NGRV,NDIR,S)                                      HSCAL001
      DIMENSION VV(111),S(11)                                                HSCAL002
      IF(NGRV-111) 1,3,6                                                     HSCAL003
    1 DELV=VV(2)-VV(1) $ DO 2 N=NGRV,111                                     HSCAL004
    2 VV(N) = VV(N-1) + DELV                                                 HSCAL005
    3 DO 5 I=1,11 $ II=I $ IF(NDIR) 4,4,5                                    HSCAL006
    4 II = 12-I                                                              HSCAL007
    5 S( I) =VV(1)*II-10) $ RETURN                                           HSCAL008
    6 WRITE (51,10) NGRV  $  RETURN                                          HSCAL009
   10 FORMAT(14H1ERROR IN NGRV ,I10/(10E12.3))                               HSCAL010
      END                                                                    HSCAL011
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      SUBROUTINE TZPIX(FT,TOL,FZ,NLINE,XMIN,XMAX,NGX,YMIN,YMAX,DELC,IDR)TZFIX001
      DIMENSION LTHV(25), LCHV(35)                                      TZFIX002
      COMMON/SET2/NP(20),IT,KT,IN                                       TZFIX003
      COMMON/XY/LTXY(51,14),LCXY(51,14),XX(111),YY(51),CC(35),          TZFIX004
     1JD,TT(25),LABFL(8),LABZ,LABX(4),LABY(4),LABC(3),LABWP(3),LABWP(3), TZFIX005
     2LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI,LERTP                      TZFIX006
      COMMON/DYE/ID,MAX,KAX,X(500),Y(500),Z(500),T(500),C(500)          TZFIX007
       DATA(LCHV=1H1,1H1,1H1,1H1,1H1,1H1,1H1,1H1,1H2,1H2,1H2,1H2,1H3,1H3,TZFIX008
     18H66666666,1H77777777,1H88888888,1H99999999,1HAAAAAAAA,1HBBBBBBBB,TZFIX009
     28HCCCCCCCC,1HDDDDDDDD,1HEEEEEEEE,1HFFFFFFFF,1HGGGGGGGG,1HHHHHHHHH,TZFIX010
     38HIIIIIIII,1HJJJJJJJJ,1HKKKKKKKK,1HLLLLLLLL,1HMMMMMMMM,1HNNNNNNNN,TZFIX011
     48HPPPPPPPP,1HQQQQQQQQ,1HRRRRRRRR,1HSSSSSSSS,1HTTTTTTTT,1HUUUUUUUU,TZFIX012
     58HVVVVVVVV,1HW=======,1HXXXXXXXX,1HYYYYYYYY,1HZZZZZZZZ,1H########)TZFIX013
       DATA(LTHV=                                  1HAAAAAAAA,1HBBBBBBBB,TZFIX014
     18HCCCCCCCC,1HDDDDDDDD,1HEEEEEEEE,1HFFFFFFFF,1HGGGGGGGG,1HHHHHHHHH,TZFIX015
     28HIIIIIIII,1HJJJJJJJJ,1HKKKKKKKK,1HLLLLLLLL,1HMMMMMMMM,1HNNNNNNNN,TZFIX016
     38HPPPPPPPP,1HQQQQQQQQ,1HRRRRRRRR,1HSSSSSSSS,1HTTTTTTTT,1HUUUUUUUU,TZFIX017
     48HVVVVVVVV,1HW=======,1HXXXXXXXX,1HYYYYYYYY,1HZZZZZZZZ)           TZFIX018
      KNALB = 20202020202020208                                         TZFIX019
      DO 3124 N=1,714 $ LTXY(N) = KNALB                                 TZFIX020
 3124 LCXY(N) = KNALB                                                   TZFIX021
      TMIN=FT-TOL $TMAX=FT+TOL $JD=IDR $NGRX=ABSF(NGR)$NDIR=1$NGRX=NGR  TZFIX022
      ZMAX=FZ+.00001 $ZMIN=FZ-.00001                                    TZFIX023
      IF (NGR) 17,17,18                                                 TZFIX024
   17 NDIR = -1  $  NGRX =-NGR                                          TZFIX025
   18 CMIN=-.5*DELC  $ CMAX=34.5*DELC                                   TZFIX026
      CALL RSCALE( XMIN,XMAX,NGRX,DX,XX)                                TZFIX027
      CALL RSCALE(YMIN,YMAX,51,DY,YY)                                   TZFIX028
      CALL RSCALE( CMIN,CMAX,35,DC,CC)                                  TZFIX029
      CALL RSCALE(TMIN,TMAX,25,DT,TT)                                   TZFIX030
      IF (NLINE) 23,23,22                                               TZFIX031
   22 CALL WAREA (XMIN,XMAX,YMIN,YMAX,NGRX,NDIR,NLINE , DX,DY)          TZFIX032
   23 PAUSE  $ REWIND IN                                                TZFIX033
      M = MAX       $    PAUSE      $REWIND IN                         TZFIX034
      READ(IN,50) KAX,ID,LABEL,NN,LABZ,LABX,LABY                        TZFIX035
      WRITE(KT,50)KAX,ID,LABEL,NN,LABZ,LABX,LABY                        TZFIX036
      READ(IN,55)LABC,LABWP,LABWP,LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI TZFIX037
      WRITE(KT,55)LABC,LABWP,LABWP,LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTITZFIX038
   50 FORMAT(1H0,I2,1H,A8,1H,8A8)                                       TZFIX039
   55 FORMAT(1H0,9A8)                                                   TZFIX040
                                              NT=0 $ DO 16 K=1,KAX $NGP=NP(K)TZFIX041
      READ(IN) ID,MAX,(X(M),Y(M),Z(M),T(M),C(M),M=1,MAX )               TZFIX042
C     WRITE(KT,10) K,MAX,(J,X(J),Y(J),Z(J),T(J),C(J),J=1,MAX)           TZFIX043
   10 FORMAT(1H1,3I5,5F20.4/(I10,5F20.4))                               TZFIX044
    2 IF(NGP) 19,16,3                                                   TZFIX045
    3 DO15M=1  ,MAX $ NGOT=INSIDEF(TMIN,T(M),TMAX) $ GO TO (4,15),NGOT  TZFIX046
    4                 NGOZ=INSIDEF(ZMIN,Z(M),ZMAX) $ GO TO (5,15),NGOZ  TZFIX047
    5                 NGOX=INSIDEF(XMIN,X(M),XMAX) $ GO TO (6,15),NGOX  TZFIX048
    6                 NGOY=INSIDEF(YMIN,Y(M),YMAX) $ GO TO (7,15),NGOY  TZFIX049
    7                 NGOC=INSIDEF(CMIN,C(M),CMAX) $ GO TO (9,8),NGOC   TZFIX050
    8 C(M) = CMAX                                                       TZFIX051
    9 NT=(T(M)-TMIN)/DT + 1.0                                           TZFIX052
C   9 NT = NT + 1  $  IF(NT-26) 12,11,11                                TZFIX053
C  11 NT=1                                                              TZFIX054
   12 NY = (Y(M)-YMIN)/DY + 1.0                                         TZFIX055
      NX = (X(M)-XMIN)/DX+1.0                                           TZFIX056
      NC = (C(M)-CMIN)/DC+1.0                                           TZFIX057
      LM1=LCHV(NC) $ LM2 =LTHV(NT) $ NGR1= NGRX+1                       TZFIX058
      CALL POSTS(NGR1,NDIR,NX,NY,LM1,LCXY)                              TZFIX059
      CALL POSTS(NGR1,NDIR,NX,NY,LM2,LTXY)                              TZFIX060
   15 CONTINUE                                                          TZFIX061
   16 CONTINUE                                                          TZFIX062
   19 REWIND IN                                                         TZFIX063
      WRITE(51,30)LABEL,ID,LERDA,LERTI,LERX,LERY,LERZ                   TZFIX064
   60  FORMAT(1X,80HCONSECUTIVE GRAPHING SYMBOLS REPRESENT SEQUENTIAL TITZFIX065
     1ME WHERE  9X,5(1X,A1,1H=F6.2,1H,))                                TZFIX066
      WRITE(51,70)LABY,LABX,FZ,LABZ,LABC,TMIN,TMAX,LARTI                TZFIX067
      WRITE OUTPUT TAPE 51,60,(LTHV(J),TT(J),J=1,4)                     TZFIX068
      WRITE(51,40)(LTHV(J),TT(J),J=6,25)                                TZFIX069
      CALL DYG2 (XX,YY,LTXY,NGRX,NDIR  )                                TZFIX070
      WRITE(51,29)       ID,LERDA,LERTI,LERX,LERY,LERZ                  TZFIX071
   30 FORMAT(1H1,18X 8AH/7H STUDY AR,5H  ,  13HRELEASE DATE A8,4H AT A8,TZFIX072
     1 5H  ,  21HRELEASED LOCATION X =A8,5H  ,  3HY =A8,5H  ,  3HZ =A8 )TZFIX073
   29 FORMAT(                7H1STUDY AR,5H  ,  13HRELEASE DATE A8,4H AT A8,TZFIX074
     1 5H  ,  21HRELEASED LOCATION X =A8,5H  ,  3HY =A8,5H  ,  3HZ =A8 )TZFIX075
      WRITE(51,70)LABY,LABX,FZ,LABZ,LABC,TMIN,TMAX,LARTI                TZFIX076
   70 FORMAT(20X  ,4A8,2X,6HVERSUS,2X,4A8/1X,24HFIXED SAMPLING DEPTH OF TZFIX077
     1 ,F4.1,1X,AH,1X,3A8,3X,4HFROM,2X,F6.2,4H TO ,F6.2,1X,A8,15H AFTER TZFIX078
     2RELEASE.)                                                         TZFIX079
      WRITE(51,35)                                                      TZFIX080
   35 FORMAT(53H GRAPHING SYMBOLS REPRESENT DYE CONCENTRATIONS WHERE.)  TZFIX081
      WRITE (51,40) (LCHV(J),CC(J), J = 1, 35)                          TZFIX082
   40 FORMAT (12(1X,A1,1H=F6.2,1H,) /12(1X,A1,1H=F6.2, 1H,) /           TZFIX083
     2        11(1X,A1,1H=F6.2,1H,) , 1X,A1, 1H=F6.2)                  TZFIX084
      CALL DYG2(XX,YY,LCXY,NGRX,NDIR )                                  TZFIX085
      END                                                               TZFIX086
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      SUBROUTINE GLINE(    NGR,NW,DELC)                                      GLIN 001
C     SUBROUTINE GLINE FOR TYZ                                               GLIN 002
C     USE FOR TYZFIX. CHECK COMMON AND READ BINARY LIST                      GLIN 003
      COMMON/SET/MP(75),XW(20),XMIN,XMAX,NG,LERTIV(74),LERXV(74)             GLIN 004
      COMMON/IDYE/     ID,LABEL(8),LABZ,LABX(4),LABY(4),LABC(3),LABP(3),     GLIN 005
     1LABWP(3),LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTI,LERTE,NK,SUMCX,        GLIN 006
     2SUMCWX                                                                 GLIN 007
      COMMON/DYE/    MAX,KAX,V(500),R2(500),R3(500),R1(500),C(500),          GLIN 008
     1FIL(3161)                                                              GLIN 009
      COMMON/LINE/COUNT(111),PCC(111),PWW(111),SCC(111),SWW(111),VV(111)GLIN 010
     1,CC(51),VW(50),NGWOU(75),RMIN(3),RMAX(3),VMIN,VMAX,DV,NGRV,TCUR,      GLIN 011
     2NDIR,IT, KT,IN                                                         GLIN 012
      NGRV=NGR $ NDIR=1          $        IF(NGR) 1,1,2                       GLIN 013
    1 NDIR = -1   $  NGRV = -NGR                                             GLIN 014
    2 CONTINUE          $ CALL BSCALE(VMIN,VMAX,NGRV,DV,VV)                  GLIN 015
   50 FORMAT(1H0,I2,1H,A8,1H,8A8)                                            GLIN 016
      NK=0$SUMCX=0.0$SUMWX=0.0$DO18N=1,NGRV$SCC(N)=0.0$SWW(N)=0.0            GLIN 017
   18 COUNT(N)=0.0$LERTI=LERTIV(NG)$LERX=LERXV(NG)                           GLINE 18
      READ(IN,50) KAX,ID,LABEL,NN,LABZ,LABX,LABY                             GLIN 019
      WRITE(KT,50)KAX,ID,LABEL,NN,LABZ,LABX,LABY                             GLIN 020
      READ(IN,55)LABC,LABP,LABWP,LERDA,LE    ,LE , LERY,LERZ,LABTE,LABTI GLIN 021
      WRITE(KT,55)LABC,LABP,LABWP,LERDA,LERTI,LERX,LERY,LERZ,LABTE,LABTIGLIN 022
   55 FORMAT(1H0,9A8)                                                        GLIN 023
      WRITE(KT,60)LABEL,ID,LERDA,LERTI,LERX,LERY,LERZ,RMIN(2),LABY,          GLIN 024
     1RMIN(1),RMAX(1),LABTI,LABC,LABX,RMIN(3),LABZ                           GLIN 025
   60 FORMAT(1H1,18X 8A8/7HOSTUDY A8, 4H  , 13HRELEASE DATE A8,4H AT A8,GLIN 026
     1 5H  ,  21HRELEASED LOCATION X =A8,5H  ,  3HY =A8,5H  ,  3HZ =A8/ GLIN 027
     2                                  11HOFIXED Y = F7.1,                GLIN 028
     3 1X 4A8,13X10HFIXED T = 5HFROM F6.2,4H TO F6.2,1XA8,1X                GLIN 029
     4 13HAFTER RELEASE/                                                    GLIN 030
     5 20X3A8,5X3HVS.,5X4A8,6X9HFIXED Z =F6.1,2XA8/)                        GLIN 031
      WRITE(KT,70)                                                          GLIN 032
   70 FORMAT(1H02X1HN,16X4HFROM,10X2HTO,8X4HDELX,6X6HAVEH C                 GLIN 033
     17X5HAV. =,7X5HCDELX,8X4HMASS,7X5HSUM C, 4X8HSUM MASS//)               GLIN 034
      DO 11 K=1,KAX$NGP=NGROU(K)                                            GLINE 35
               READ(IN) ID,MAX,(V(M),R2(M),R3(M),R1(M),C(M),M=1,MAX)        GLIN 036
      IF (NGP)19,11,4                                                       GLIN 037
    4 INIP=-1$DO9 M=1,MAX                                                   GLIN 038
      NGOR1=INSIDEF(RMIN(1),R1(M),RMAX(1))$GO TO (6,9),NGOR1                GLIN 039
    6 NGOR2=INSIDEF(RMIN(2),R2(M),RMAX(2))$GO TO(7,9),NGOR2                 GLIN 040
    7 NGOR3=INSIDEF(RMIN(3),R3(M),RMAX(3)) $GO TO (8,9),NGOR3               GLIN 041
    8 VQ=V(M) $ CQ=C(M) $ IF(M-INIP-1)3,5,3                                 GLIN 042
    3 INIP=M $ INIT=0                                                       GLIN 043
    5 CALL VINT(N,INIT,VQ,CQ) $ INIP=M                                      GLIN 044
    9 CONTINUE                                                              GLIN 045
   11 CONTINUE                                                              GLIN 046
   19 IF(NK    ) 12,21,12                                                   GLIN 047
   12           DO 14N=1,NGRV$IF(COUNT(N)) 14,14,13                        GLIN 048
   13 SCC(N)=SCC(N)/COUNT(N) $ SWW(N)=SWW(N)/COUNT(N)                       GLIN 049
   14 CONTINUE $  TCC=0.0  $  TWW=0.0                                       GLIN 050
      CALL DYG1(SCC,DELC,NDIR,LABC,       8H*********)                   GLIN 051
      CALL DYG1(SWW,DELC,NDIR,LABC,       8HMMMMMMMMM)                   GLIN 052
   30 FORMAT(3I10,4F20.5)                                                   GLIN 053
      A = VV(1)-.5*DV                                                       GLIN 054
      DO 15 N=1,NGRV  $ TCC=TCC+SCC(N)                                      GLIN 055
   15 TWW=TWW+SWW(N)$CALL SUB(SCC,NGRV,PCC)$CALL SUB(SWW,NGRV,PWW)          GLIN 056
      DO 17 N=1,NGRV                                                        GLIN 057
      PCC(N)=PCC(N)/TCC $ PWW(N) =PWW(N)/TWW $ B=A+DV                       GLIN 058
      WRITE(KT,40)K,N,A,VV(N),B,SCC(N),SWW(N),PCC(N),PWW(N),COUNT(N),       GLIN 059
     1TCC,TWW  $  AWW                                                       GLIN 060
   17 CONTINUE                                                              GLIN 061
   40 FORMAT(2I4,3F8.2,4F10.3, F8.0,2F20.3)                                 GLIN 062
      DC = .0200000001 $ CALL DYG1(PCC,DC,NDIR,LABP       ,8HCCCCCCCCC  ) GLIN 063
                         CALL DYG1(PWW,DC,NDIR,LABWP,      8HWWWWWWWWW  ) GLIN 064
   21 REWIND IN $ RETURN                                                    GLIN 065
      END                                                                   GLIN 066
```